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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS.

FIELD OPERATIONS OF THE BUREAU OF SOILS,

123358

1902.

[FOURTH REPORT.]

BY

MILTON WHITNEY, Chief.

WITH

ACCOMPANYING PAPERS BY ASSISTANTS IN CHARGE OF FIELD PARTIES.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1903.

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(No. 8.)

A JOINT RESOLUTION **providing for the printing annually of the Report on Field Operations of the Division of Soils, Department of Agriculture.**

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That there be printed seventeen thousand copies of the Report on Field Operations of the Division of Soils, Department of Agriculture, for nineteen hundred, of which three thousand copies shall be for the use of the Senate, six thousand copies for the use of the House of Representatives, and eight thousand copies for the use of the Department of Agriculture; and that annually hereafter a similar report shall be prepared and printed, the edition to be the same as for the report herein provided.

Approved, February 23, 1901.

[On July 1, 1901, the Division of Soils was reorganized into the Bureau of Soils.]

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BUREAU OF SOILS.

Milton Whitney, *Chief of Bureau.*
Albert G. Rice, *Chief Clerk.*

SCIENTIFIC STAFF.

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Frank K. Cameron, in charge of Laboratory of Soil Chemistry.
F. H. King, in charge of Soil Management.
George T. McNess, in charge of Tobacco Investigations.
Thomas H. Means, in charge of Soil Survey, United States.
Clarence W. Dorsey, in charge of Soil Survey, Insular Possessions.

ASSISTANTS IN CHARGE OF SOIL SURVEY PARTIES.

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Louis Mesmer.
Thomas A. Caine.
F. W. Taylor.
T. D. Rice.
Frank Bennett, Jr.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., March 20, 1903.

SIR: I have the honor to transmit herewith the manuscript report, with accompanying illustrations and maps, of the field operations of the Bureau of Soils in 1902, the publication of which is authorized by joint resolution of the Fifty-sixth Congress, second session.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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FIELD OPERATIONS OF THE BUREAU OF SOILS, 1902.

By MILTON WHITNEY, Chief.

GENERAL REVIEW OF THE WORK.

ORGANIZATION.

The organization of the Bureau of Soils has been the same as during the preceding year. The work in the United States proper has been under the direction of Mr. Thomas H. Means, while that in the insular possessions has been under the charge of Mr. Clarence W. Dorsey.

Fifteen soil survey parties have been maintained during most of the year. So far as possible, the assignments of the field parties are made for periods of three months to facilitate the transfers of assistants which are occasionally necessary and to permit of the bringing together of two or more parties on a large or difficult area which it is desirable to survey in its entirety during the same season.

The field men have been kept out for the first time during the entire twelve months, being assigned to areas in the Northern States during the spring and summer months and to areas in the Southern States during the fall and winter months. The temperature during the latter season is favorable for work in the Gulf States, but the usual large amount of rain interferes materially with the prosecution of the work, which progresses more slowly and costs more per square mile for this reason. Still, it has seemed desirable and necessary to meet the great demands that are made to keep the parties out in the field for the entire year. This has made possible the completion of the very large amount of field work embraced in this report.

In July Mr. Means was temporarily detached from the soil survey work to accompany Mr. Thomas H. Kearney, of the Bureau of Plant Industry, on a trip to Egypt, Italy, and Algeria to study the alkali-resistant crops and incidentally the methods of reclamation of alkali

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lands. The results of this trip will appear in several separate publications. On reporting back for duty about the 1st of October, Mr. Means was again assigned to the charge of the soil survey in the United States, but on the termination of the season's work was, at his own request, placed in charge of the alkali reclamation work, which is giving great promise of large returns of economic importance.

In January, 1902, at the request of the Porto Rico experiment station, through the Office of Experiment Stations of this Department, Mr. Dorsey went to Porto Rico in charge of a soil survey party and surveyed a strip across the island from Arecibo to Ponce. On the completion of this work and on the request of the War Department, Mr. Dorsey was temporarily transferred to the Philippine civil service and assigned to work in the Philippine Islands. The results of his work in Porto Rico are given in this volume; a report on that in the Philippine Islands will probably be given, by permission of the War Department, in the next annual volume. It is the intention to have Mr. Dorsey return during the early part of next year to assume charge of the soil survey in the United States and to assign one of the other men to the Philippine work. With the present reading of the Agricultural appropriation bill it will not be possible to conduct soil survey work in our insular possessions except as such work may be paid for by their local experiment stations or other organizations.

With the increased appropriations provided by Congress for the work of the Bureau, it is proposed to have twenty parties in the field during the next calendar year.

PROGRESS AND COST OF THE SOIL SURVEY.

Prior to the field season of 1902 there were surveyed and mapped, on the scale of 1 inch to the mile, 15,871 square miles, or 10,157,440 acres. During the field season of 1902, covered by the present report, there have been surveyed and mapped on the same scale 17,996 square miles, or 11,517,440 acres. The surveys of 1902 cover thirty-six areas in twenty-six States and Territories, including Porto Rico.

The surveys in the Colorado Desert and Los Angeles areas, California, Gadsden County area, Florida, and the Parmele area, North Carolina, not having been completed in the calendar year, the reports of the work will not be published until the next annual report. For convenience in reporting the work completed, the report on Field Operations of the Bureau of Soils is made to conform to the calendar year and not to the Government fiscal year.

The following table shows the States and Territories in which work has been done, the names of the areas surveyed, their extent, the cost per square mile, and the total cost of each survey in 1902:

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Areas surveyed and mapped and cost of field work for calendar year ended December 31, 1902.

State or Territory.	Area.	Area surveyed.	Cost per square mile.	Total cost.
		Sq. miles.	*Dollars.*	*Dollars.*
Alabama	Perry County	762	1.01	770.20
Arizona	Yuma area	99	4.42	437.95
Arkansas	Stuttgart area	251	2.81	704.34
California	Imperial area (portion completed.)	400	6.75	2,700.00
Do	Los Angeles area (portion completed.)	40	4.10	164.00
Colorado	Arkansas Valley area	945	3.58	3,381.61
Florida	Gadsden County (portion completed.)	225	3.67	825.75
Idaho	Lewiston area	308	2.15	662.65
Illinois	Clay County	460	.96	[a] 441.22
Do	Clinton County	491	.89	[b] 434.72
Do	St. Clair County	650	1.43	[c] 929.16
Do	Tazewell County	645	1.40	[d] 903.50
Indiana	Posey County	387	2.29	886.23
Iowa	Dubuque area	440	.92	406.08
Kansas	Wichita area	465	1.92	894.34
Kentucky	Union County	361	2.32	839.15
Mississippi	Smedes area	463	1.82	841.80
Missouri	Howell County	919	1.09	1,004.04
Montana	Billings area	107	4.87	520.80
New Jersey	Trenton area	810	2.16	1,752.89
New York	Bigflats area	223	2.09	466.90
Do	Lyons area	515	1.52	785.20
North Carolina	Hickory area	988	1.23	[e] 1,217.85
Do	Parmele area (portion completed.)	236	1.80	424.80
Do	Mount Mitchell area	497	1.24	[f] 617.40
North Dakota	Grand Forks area	314	2.74	860.36
Ohio	Columbus area	472	1.53	720.92
Do	Toledo area	403	.92	370.50
Porto Rico	Arecibo to Ponce	330	5.02	[g] 1,655.55
South Carolina	Abbeville area	1,006	1.07	1,076.86
Do	Darlington area	600	1.40	840.00
Texas	Brazoria area	845	2.28	1,930.07
Do	Vernon area	277	2.50	692.55
Virginia	Albemarle area	1,410	1.62	2,289.92
Washington	Walla Walla area	201	2.60	523.00
Wisconsin	Janesville area	451	1.67	752.40
Total and average		17,996	1.93	34,724.71

[a] $134.40 of this amount paid by Illinois experiment station.
[b] $172.90 of this amount paid by Illinois experiment station.
[c] $417.76 of this amount paid by Illinois experiment station.
[d] $351 of this amount paid by Illinois experiment station.
[e] $488.27 of this amount paid by North Carolina department of agriculture.
[f] $245.63 of this amount paid by North Carolina department of agriculture.
[g] $300 of this amount paid by Porto Rico experiment station.

The high rate of cost per square mile shown in the case of the Imperial area is due to the fact that a considerable amount was expended during 1902 for teams, camp equipment, etc., which will be used for the completion of the 600 additional square miles that will be surveyed in 1903. The cost per square mile will be very materially reduced when the entire area is considered.

The average, taking into account the salaries of the men for the periods actually in the field and their transportation and subsistence

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expenses within the area, but not including transportation to and from the area, has amounted to approximately $1.93 per square mile, or, deducting the amount paid by the cooperating institutions, the net cost to the Department of Agriculture has been $1.81 per square mile. The total cost of the work, including with the above transportation to and from the area, the annual salaries of the men, their subsistence and supplies, inspection, preparation of reports, and other office work, amounts to about $2.87 per square mile, or about 33 cents per hundred acres. The following table shows the areas that have been surveyed during the year 1902 and the areas previously reported, with the total in square miles and acres by States. The area surveyed in 1902 was 17,996 square miles, and the area previously reported was 15,871 square miles, making a total of 33,867 square miles, or 21,674,880 acres.

Areas surveyed to December 31, 1902.

State or Territory.	Surveyed during 1902.	Previously reported.	Total.	
	Sq. miles.	*Sq. miles.*	*Sq. miles.*	*Acres.*
Alabama	762		762	487,680
Arizona	99	449	548	350,720
Arkansas	251		251	160,640
California	440	2,131	2,571	1,645,440
Colorado	945		945	604,800
Connecticut		245	245	156,800
Florida	225		225	144,000
Georgia		571	571	365,440
Idaho	308	399	707	452,480
Illinois	2,246		2,246	1,437,440
Indiana	387		387	247,680
Iowa	440		440	281,600
Kansas	465		465	297,600
Kentucky	361		361	231,040
Louisiana		202	202	129,280
Maryland		2,147	2,147	1,374,080
Massachusetts		143	143	91,520
Michigan		828	828	529,920
Mississippi	463	656	1,119	716,160
Missouri	919		919	588,160
Montana	107		107	68,480
New Jersey	810	493	1,303	833,920
New Mexico		128	128	81,920
New York	738	260	998	638,720
North Carolina	1,721	2,874	4,595	2,940,800
North Dakota	314		314	200,960
Ohio	875	480	1,355	867,200
Pennsylvania		938	938	600,320
Porto Rico	330		330	211,200
South Carolina	1,606		1,606	1,027,840
Tennessee		547	547	350,080
Texas	1,122	215	1,337	855,680
Utah		794	794	508,160
Virginia	1,410	1,062	2,472	1,582,080
Washington	201	309	510	326,400
Wisconsin	451		451	288,640
Total (36 States and Territories)	17,996	15,871	33,867	21,674,880

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Three reports have already been issued on the soil survey work, the first being Report No. 64, field operations in 1899, containing 198 pages and 11 maps; the second a report of the field operations in 1900, containing 473 pages and 24 maps, and the third a report of field operations in 1901, containing 647 pages and 31 maps; each of these reports being appropriately illustrated.

COOPERATION WITH STATE ORGANIZATIONS.

During the year the Bureau has continued its cooperation with various State and other organizations, such as experiment stations, boards of agriculture, and other branches of the Federal and State governments. In some instances, as in the case of the North Carolina department of agriculture, the college of agriculture and agricultural experiment station of Illinois, the Porto Rico experiment station, and the Utah experiment station, this cooperation has taken the form of active official and financial participation in the work. In the work done, as indicated in the footnote to the table showing the areas surveyed and the cost of the field work, the organizations referred to in North Carolina, Illinois, and Porto Rico have defrayed in part the field expenses of the parties making the surveys, while in Utah the expenses of the drainage work have been partly met by the Utah experiment station. The Bureau has also cooperated with the agricultural and economic survey of North Dakota in connection with the surveys made in the Grand Forks area, with the U. S. Geological Survey in work on the Needles to Yuma area, California, and with the War Department of the Federal Government in inspection work in New York. The cooperative work in Maryland in connection with the Maryland geological survey and the Maryland experiment station has been temporarily suspended because necessary base maps were not available. These maps, however, are in course of preparation, and cooperative work in this State will be resumed at an early date.

RESULTS OF THE SOIL SURVEY.

BIGFLATS AREA, NEW YORK.

The Bigflats area, comprising parts of Chemung and Steuben counties, N. Y., and Bradford County, Pa., has an area of about 223 square miles, or 143,040 acres. The greater part of the surface consists of a high table-land of much-eroded shale, with a maximum elevation of 1,900 feet. The soil in this rough table-land is not very fertile, and the extreme wash makes it difficult to improve. The Chemung Valley with its tributaries from 500 to 700 feet lower than the table-land, forming the remainder of the area, gives it its agricultural importance. The soils are rich, deep, and generally easily cultivated. They are derived from the wash of the hills and from reworked

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glacial till or from an intermingling of the two materials. The glacial till in the valley is of great depth. At one time the area was of very considerable importance in the production of wheat and live stock, but to-day, though general farming is the characteristic phase of the agriculture, the principal money crop is tobacco. Celery is also specialized. The farms are of moderate size, and the value of agricultural land ranges from $13 in the hill country to $100 in the valley.

The Hagerstown shale loam, covering 108,800 acres, or 76.1 per cent of the area surveyed, is the most extensive, though not the most important agriculturally, of the soils in the area, and occupies nearly the whole area of the table-land. The average depth of soil is probably 7 inches, but the depth varies greatly, and the soil is often thin on the steep slopes, the parent rock outcropping in some locations or coming so near the surface as to render plowing difficult. The original forest covering has been largely removed. Washing is severe and soil exhaustion prevalent throughout the area. Many of the hill farms have been abandoned. General farm crops are produced. Beans and potatoes, the latter of fine quality, are important products. Many of the hills should be abandoned for cultivated crops and be left to forest. A fine grade of white pine formerly grew in these hills.

The Miami gravelly loam, covering 15,680 acres, or 11 per cent of the total area of the survey, is a loose, porous, well-drained soil, occupying about half of the area of the valley. The soil has a good depth, averaging 16 inches, and where the rock fragments are not excessive it is easily cultivated. There are areas where the stone content reaches 60 per cent of the soil mass. The fragments are largely shale, but other transported rock is present. The soil occupies low rolling hills, gently sloping plains, and glacial dumps. All the general farm crops are produced. Special attention is given to tobacco, which yields from 1,300 to 2,000 pounds per acre. The leaf is of superior quality—generally considered the best grown in the area.

The Elmira shale loam, covering 8,512 acres, or 6 per cent of the area surveyed, is a light gray loam, mellow, and easily cultivated. The subsoil is very stony, and there are some areas, marked by gravel symbol on the soil map, where the surface is thickly strewn with shale fragments. The soil is derived from wash from the shale hills and occupies sloping plains or fan-shaped deltas reaching out from the base of the hills into the valley. The general farm crops and tobacco are produced. The tobacco is of good quality, but both for this crop and for others heavy annual applications of barnyard manure are necessary. The cultivation of tobacco is successful even on areas so stony as to appear little else than rock piles.

The Elmira fine sandy loam, covering 5,632 acres, or 3.9 per cent of the area surveyed, occupies the bottoms and occasional terraces along Chemung and Newtown creeks. It is an alluvium formed by the

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blending of washings from the shale hills and glacial deposits. Some of the areas are subject to overflow, but are cultivated, and are benefited by the rich sediments left by the overflow water. In fertility and general productiveness this soil is the first in the area. The tobacco grown on this soil is heavier, but the leaf is coarser, the color is not as good, and the price is lower than for the product of the Elmira gravelly loam or the Elmira shale loam.

The Elmira silt loam, covering 1,920 acres, or 1.3 per cent of the area, is composed of the finer particles of wash from the shale hills. All the ordinary farm crops are grown, and in addition to these tobacco, which does well, especially where the fields are underdrained. Tobacco fields are heavily fertilized with barnyard manure, from one to two carloads often being applied to an acre. The tobacco is of good quality and suitable for wrappers.

The Meadow, covering 1,920 acres, or 1.3 per cent of the area, occurs in small, narrow strips, adjacent to swamps and water courses. The soil texture varies from a loam, near swamps in the hill country, to lighter silty and sandy soils near the streams. The areas are too wet for cultivation without draining. The Meadow is generally in grass and is used for pasturage.

There are 576 acres of peat in the area, all lying in the valley. This soil when drained is very valuable, being used chiefly for the production of celery, although to some extent cabbages and onions are also grown.

In the Bigflats area the adaptation of soils to crops is comparatively well worked out. The methods of cultivation are generally good, as far as the general farm and special crops are concerned, but much more could be made of the fruit industry by the adoption of more modern methods of orcharding.

Taken as a whole the farmers are in a prosperous condition, the exceptions being chiefly in the hill country, where the natural features of soil and topography are heavy handicaps to even the wisest and most industrious.

LYONS AREA, NEW YORK.

The Lyons area covers 515 square miles, or 329,664 acres, largely in Wayne County, western New York, and borders Lake Ontario. The Erie Canal and the New York Central Railroad both cross it. Newark is the largest town; Lyons, Clyde, and Palmyra are other important market places. Surface features are diversified, being a succession of glacial hills and valleys. The southern part especially is quite broken, the hills and ridges, with abrupt slopes running north and south, rising 100 to 160 feet above the intervening valleys. The northern part has a more gently rolling surface, with general inclination toward the lake.

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One of the important industries is the production of apples. There are 700,000 trees in the orchards. Every part of the crop is utilized. The perfect fruit is barreled and shipped to market, the poorer evaporated, canned, or made into cider or vinegar. Small evaporators are found on all the important fruit farms. Other important products besides the general farm crops are other tree fruits, berries, sugar beets, truck (potatoes, cabbages, onions, pease, beans), and peppermint. The last is not so extensively produced as formerly.

The farms vary in size from 20 to 200 acres, averaging about 70 acres. Seventy-five per cent of the farms are owned and tilled by the farmers.

The Miami stony loam, covering 158,400 acres, or 48.4 per cent of the area surveyed, is a light-brown sandy loam from 7 to 10 inches deep, resting on a sandy loam subsoil. Both soil and subsoil contain quantities of gravel and stones, varying in amount from 5 to 40 per cent in the former and from 5 to 50 per cent in the latter. This is the most important type found in the area. Its greatest development is found in the southern and central parts of the area. The surface is very much broken and diversified. Sometimes the slopes are steep and difficult to cultivate. The drainage is good. This soil is derived from weathering of glacial drift. Almost all the area is under cultivation, and nearly all the crops suited to it are produced. Apples and other tree fruits are important products, after which come grass, corn, oats, wheat, sugar beets, and potatoes, while relatively less important are cabbages, beans, green pease, peppermint, tobacco, and berries. Grass, chiefly timothy and clover, yields from 1 to 2½ tons of hay to the acre. Yield per acre of corn, 25 bushels; of wheat, 12 bushels; of oats, 25 bushels; and of potatoes, 75 bushels. Sugar beets produce from 8 to 11 tons per acre. Sugar content and purity good. Pease are grown for canning purposes. The vines are cut green and pease shelled by machinery. They yield 1½ tons per acre. Cabbage yields from 4 to 12 tons.

The Alton stony loam, covering 38,208 acres, or 11.6 per cent of the area, is a silty or sandy soil, 6 to 10 inches deep, containing 25 to 60 per cent of stones and gravel, and resting on sandy loam or clayey sandy loam, in which the quantity of gravel and stones is often greater than in the surface soil. The rock fragments are chiefly granite, sandstone, and limestone. Many large bowlders are found on the surface. Areas of this soil are confined to the northern part of the area surveyed, where it generally occupies the rolling and practically level uplands. The drainage is usually good, but some of the flatter areas would be benefited by underdrainage. The soil is chiefly composed of weathered glacial material, but small areas are partly residual, being derived from outcropping ridges of the Clinton and Niagara limestones.

The Alton stony loam is the least fertile soil in the area. Where the

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gravel content is high, the soil is leachy, droughty, and difficult to till. Apples and other fruits, however, do well. Some areas produce fairly good crops of beans, corn, wheat, and hay. Cabbages, buckwheat, berries, and grapes are secondary in importance. It is probable that this soil would do well for grapes. At present the vineyards are not extensive.

The Meadow, covering 35,008 acres, or 10.6 per cent of the area, is the third in extent of the nine soil types of the area. The soil is a fine sandy loam or clay, and the areas include scattered patches of muck. The areas are wet and too low to be drained by gravity. They are used for pastures during the drier months. One area, the Montezuma Marsh, supports a thrifty growth of flags, which are cut for use in manufacturing chair bottoms. The Meadow areas also produce a coarse hay, and some are profitably utilized for basket osiers.

The Miami fine sandy loam, covering 29,824 acres, or 9 per cent of the area, is a glacial soil, occupying broad expanses in the central part of the area surveyed and smaller tracts in other parts. It is found in the gently rolling, level, and low-lying areas along the smaller streams, and often needs artificial drainage. It is therefore cold and late. Properly drained, the yield of crops would be greatly increased and the adaptation of the soil considerably widened. The crops grown are corn, wheat, oats, grass, sugar beets, potatoes, peppermint, onions, and osiers. Sugar beets yield from 8 to 10 tons per acre. The sugar content is high and the purity excellent. Osier culture is practiced on the wetter areas, and is quite profitable. Few orchards are found on this type. The soil is too light for grains and grasses. When drained, the soil is best adapted to potatoes, sugar beets, and onions; where wet and undrained, peppermint and osiers are the crops giving best results.

The Elmira silt loam, covering 28,096 acres, or 8.5 per cent of the total area, is largely under cultivation. It is generally free from stones, light, mellow, and easily tilled. The drainage is good, except in some of the areas of depression. The texture is quite uniform and gives evidence of formation by sedimentation in quiet water. Bodies of this soil are confined to the northern and northeastern parts of the area. It occupies the forelands of Lake Ontario and the table-lands, ridges, and steep slopes along Sodus Bay and bordering small streams. The yield per acre of wheat ranges from 10 to 20 bushels, of oats from 20 to 40 bushels, of corn from 15 to 30 bushels, of potatoes from 60 to 150 bushels, and of timothy hay from 1½ to 2½ tons. Some of the finest apple orchards in the area occupy this soil in the vicinity of Sodus Bay. Other tree fruits also flourish in that neighborhood. This soil was formerly used in the production of a fine brewing barley, but this crop has been abandoned. The soil has the property of

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holding moisture and fertilizers well and is easily brought to a high state of fertility.

The Alloway clay, covering 16,448 acres, or 4.9 per cent of the total area, occupies one large section just northwest of Clyde and many smaller ones scattered over the southern part of the area surveyed. The soil is free from stones, has imperfect drainage, and is cold and late. The surface is uniformly level or depressed. Notwithstanding the close, impervious texture of the soil and subsoil, good crops of wheat, oats, corn, and hay are produced. Sugar beets are grown. The sugar content is not quite so high as in beets produced on the Miami stony loam. Very few fruit trees are growing on this type. The best adaptation of this soil is in the production of hay and wheat, although it is also a very good type for pastures.

The Miami fine sand, covering 14,656 acres, or 4.4 per cent of the area, is an early and easily tilled soil occupying the rolling upland, level areas, knolls, and ridges, usually near small streams emptying into Sodus Bay and Lake Ontario. Originally of glacial origin, the soil materials have often been reworked and redeposited by the streams, which accounts for its marked uniformity of texture. It is well drained and may be worked almost immediately after rains. The chief crops are corn, potatoes, and berries. Raspberries are extensively grown. Several large apple orchards are to be found on this soil. Younger orchards of peaches, pears, cherries, and plums were seen. The yield of corn is moderate, but both yield and quality of potatoes are excellent. The soil on the whole is better adapted to truck, potatoes, and small fruits than to the general farm crops. The soil is leachy and does not retain fertilizers well.

The Miami loam, covering 5,184 acres, or 1.5 per cent of the area surveyed, is a deep, fertile soil lying in the larger stream bottoms. It is the youngest formation in the area and is annually being added to by the deposition of material brought down in the floods. For the ordinary farm crops and for sugar beets it is esteemed the best soil in the area, although the liability to damage by unseasonable floods tends to lessen its value somewhat. The average yield per acre of sugar beets is 14 tons, and of oats and corn the yield ranges from 30 to 60 bushels. Some peppermint is produced, and the soil seems well adapted to this crop. Little or no fertilizer is needed in cultivating the Miami loam, as the various plant foods are supplied by the sediments left by the floods.

The Muck areas, aggregated, amount to 3,840 acres, or 1.1 per cent of the area surveyed. They are usually small depressions or long strips along the streams and are shown principally on the central western part of the map. Naturally the drainage is poor, and artificial drainage is a necessary preliminary to cultivation. Fortunately ditches are easily constructed and are comparatively permanent. About two-

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thirds of the Muck area is under cultivation. Onions, potatoes, and celery are the principal crops. The first yield from 150 to 700 bushels per acre; the second yield well, but the tubers are apt to be hollow and the quality generally inferior. As in other areas, the Muck soil is very fertile, containing comparatively large proportions of organic matter. It is especially adapted to onions and celery.

There is a wide variation in the texture and adaptation of the soils of the Lyons area, and in a general way the differences are kept in view in the selection of the crops to be grown. There is room, however, for more careful differentiation, and the tendency is more and more toward intensive culture and specialization, especially on the fertile soils suited to sugar beets, small fruits, and truck, including as of first importance onions, cabbages, and celery. There would seem to be an excellent opportunity for the extension of the grape industry on some of the steeper slopes of the stony soils.

TRENTON AREA, NEW JERSEY.

The area surveyed lies in the west-central part of New Jersey and includes a small part of Pennsylvania bordering the Delaware River near the city of Trenton. The extent of the area is about 810 square miles, or 518,464 acres.

The area lies mostly within the Coastal Plain, but partly within the Piedmont Plateau. In the northern part of the area the surface is somewhat broken and rugged, some of the hills rising to an elevation of 500 feet above sea level. Although the differences are not so pronounced in the Coastal Plain region, there is still considerable variation in topography, except in the sand areas of Ocean County, where the general level is relieved only by occasional gravel-crested hills.

The Penn loam covers an area of 171,712 acres, or 33.1 per cent of the total area. It is derived from the Triassic shales and sandstones. The surface is gently rolling. The Penn loam is adapted to general farming, but is best adapted to grass and grain and to stock raising, although there is comparatively little of the latter industry. The soil is deficient in organic matter, and suffers to a considerable extent from an almost imperceptible wash, to which the thinness of the soil is attributed. The soil is generally esteemed droughty in this area, although in other places it has been found most resistant to this condition. This tendency for crops to suffer unduly from drought on this soil can be overcome by the incorporation of organic matter in the soil, and this should be done.

The Sassafras loam covers 84,672 acres, or 16.3 per cent of the area surveyed. It occupies level or gently rolling divides, ridges, and uplands in the central part of the area. The drainage is good. This soil is sedimentary in origin, is used chiefly for general farming, and is particularly well adapted to dairying. Corn, oats, wheat, and potatoes

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all produce good crops. The yield of corn varies from 35 to 70 bushels per acre; oats yield from 35 to 50 bushels; wheat from 20 to 35; and potatoes from 75 to 150 bushels. Hay yields from 1 to 2 tons per acre. Grass usually does well and makes excellent pasture of a permanent character. Of the fruits the apple has shown a particular adaptation to this soil, and its cultivation has in the past been quite successful; but many of the orchards are rapidly going to ruin, and it is doubtful if this industry can successfully compete with other more favored localities.

The third soil in order of extent is the Collington sandy loam, which covers 83,456 acres, or 16.1 per cent of the area. This soil has a rolling or hilly surface. Where the soil is deepest, light farming and trucking are practiced to advantage. Where the soil is thinner, grass and grain give excellent results, but generally this soil is best adapted to the production of corn, rye, and potatoes. Corn yields from 35 to 70 bushels per acre. With rye an average yield of 20 bushels is secured, but 35 bushels have been produced under good general conditions and heavy fertilization. The production of potatoes on this soil is very successful, the average yield being 150 bushels per acre, although nearly 300 bushels per acre have been produced. In the southern part of the area this soil is largely used for dairying purposes. The yield of hay will average about 1½ tons to the acre. Where this soil occurs in the more hilly country it is adapted to the production of the Kieffer pear.

The Norfolk sand has an extent of 50,880 acres, or 9.8 per cent of the area. It is found at all elevations, from the valley slopes of tidewater streams to the crests of some of the highest hills. It is extensively developed in the eastern part of the area. It owes its distribution to the occurrence of upland deltas, ancient forelands, and the more recent terraces bordering the larger streams. It is of purely sedimentary origin. The Norfolk sand is a typical early truck soil. Its great diversity of topography gives it a wide local range of agricultural value and use. In the forelands a fair return from grain can be secured, and while at the higher elevations grain can not be grown with profit, the stone fruits are of excellent quality and find a ready market. The Kieffer pear grown on the upland areas of Norfolk sand is of superior quality. Generally the truck grown upon this soil is of high grade. The principal truck crops are sweet corn, melons, cantaloupes, sweet potatoes, asparagus, peaches, plums, and strawberries, and other small fruits.

The Meadow covers 44,800 acres, or 8.6 per cent of the area. These Meadow areas generally occur along the streams. Along the streams traversing the Penn loam comparatively little Meadow occurs, for the reason that these streams have usually cut through the underlying rock and their escarpments are well drained and can be readily culti-

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vated. In the Penn sandy loam a much larger area occurs. Next to the Penn loam the Collington sandy loam has the least Meadow, while the Norfolk sand and Sassafras loam include large areas of land in this condition. The Meadow of the Norfolk sand has a particular value, especially where it contains thick deposits of peat, since these peat meadows are successfully used in cranberry culture.

The Elsinboro fine sand covers 26,176 acres, or 5.1 per cent of the area. It occupies the level or gently rolling uplands, and also some of the valley slopes, below the Sassafras loam. Upon the higher levels it occasionally contains considerable gravel, while generally throughout the type there is a small quantity of this material present. This soil is used largely for the production of early truck, but competition with other truck-producing areas has reduced its value as a general market-garden soil. It is, however, well adapted to the production of late truck, and large areas are planted in tomatoes and peas for canning purposes. This is developing into a profitable special industry on this soil.

The Cecil loam covers 13,952 acres, or 2.7 per cent of the area. It occupies the central portion of the trap ridge and Sourland Mountain. This soil owes its origin to the weathering of outcrops of the underlying trap rock. With the exception of the level uplands the surface of the Cecil loam is comparatively thin; on the steeper slopes there is little except the rock outcrops. Very little of this type is under cultivation, the greater part of it being in forest. Where cleared the soil produces good crops of grass, rye, buckwheat, and corn, but poor crops of wheat and potatoes. Peaches do well, having a better quality and color than those produced on the other soils of the area. Generally the type is only adapted to forest or pasture.

The Alloway clay, covering 11,904 acres, or 2.3 per cent of the area, occurs in one extensive body southwest of New Brunswick. It has a level or gently rolling surface. Owing to the impervious nature of the soil and subsoil of this type, and to its general position, it is usually wet and poorly drained. It is a sedimentary soil. The soil is heavy, cold, and refractory, and only a small part is under cultivation. The most desirable tilth and productiveness can only be secured by establishing good drainage and by gradually deepening the subsoil by use of the subsoil plow. Applications of lime are highly beneficial. When properly drained and cultivated this soil is most productive, being particularly well adapted to the grains and grasses.

The Penn sandy loam covers 10,816 acres, or 2.1 per cent of the area. Its topography is that of level to gently sloping uplands. It owes its origin to the weathering of the sandy shale of the Brunswick formation, or to an alluvial deposit of glacial origin along the rivers and within the range of their former overflow. Generally the soil is too light for use as pasture or for growing grain, with the exception

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of rye. It is particularly well adapted to early truck crops, of which early potatoes are probably the most profitable. This soil is generally well drained.

The Quinton sandy loam covers 8,640 acres, or 1.7 per cent of the area. It occupies the ridges or the crests of hills in the areas of rolling topography. It is clearly a sedimentary soil, and is used largely for general farming. It is of too light a texture for grain and grass. However, corn, rye, clover, and potatoes do fairly well. This soil shows a special adaptation for growing nursery stock and all kinds of fruits. The Elberta peach and Moore's Early grape are successfully grown. The average yield of grapes is estimated to be 2½ tons to the acre.

The Penn stony loam covers 5,632 acres, or 1.1 per cent of the area. It is practically limited to an area occupying the divide northeast of New Brunswick, and to two very small areas west of Bound Brook. This soil is of a heterogeneous composition, being derived from the glacial drift reworked with the Penn loam. Such crops as wheat, corn, rye, and clover are grown on the Penn stony loam, but it is best adapted to late truck, especially cabbages and tomatoes.

The Sassafras gravelly loam, occupying 3,712 acres, or 0.7 per cent of the area, occurs upon the sloping uplands or along the larger stream courses between Jamesburg, Hightstown, and Monmouth Junction. It owes its origin to the outcropping of the gravel bed underlying the Sassafras loam or is the result of general surface washing or erosion. This soil is usually well drained, but not droughty. Good crops of rye, clover, and potatoes are grown, but this type is especially well adapted to the stone fruits and grapes.

The Westphalia sand, which covers 1,408 acres, or 0.3 per cent of the area, occupies the slopes adjacent to the Norfolk sand and the forelands south of Helmetta and Old Bridge. It occupies but a small part of the area and little or none of it is under cultivation.

The Windsor sand occupies 512 acres, or 0.1 per cent of the area. It occurs on the hill slopes and is the result of an outcrop of the cross-bedded strata of sand and fine gravel of an ancient delta. This type is not under cultivation in this area and is covered with a growth of burr, basket, and scrub oak.

The Susquehanna gravel has the smallest distribution of any soil in the area, covering but 192 acres. It consists of coarse sand and gravel and is generally unproductive. It is used largely for road ballast.

Throughout the area the farmers follow a system of mixed agriculture which shows a somewhat advanced stage in the adaptation of crops to soils. The degree of prosperity varies in different parts of the area. The most prosperous communities are found upon the Penn loam of the consolidated area and the Sassafras loam of the Coastal Plain formation. As the distance from the area of the consolidated

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formations increases the general conditions become less prosperous. In the middle south and southwest, however, the state of the agricultural classes again becomes much better. Over 50 per cent of the area surveyed is heavily encumbered by mortgages. Considerable difficulty is experienced in securing good, reliable help on account of the proximity of numerous large cities offering a more inviting field for labor.

ALBEMARLE AREA, VIRGINIA.

The Albemarle area is situated a little to the northwest of the geographical center of the State. It is rectangular in shape, about 52 miles long north and south by 27 miles wide east and west, and comprises an area of 1,409 square miles.

This area embraces portions of three important physiographic divisions—the Piedmont Plateau, the Blue Ridge Mountains, and the Great Valley of Virginia. The Piedmont Plateau occupies the east and southeast parts of the area and presents the usual surface features of the Piedmont region, characterized by a broad plainlike surface with rolling hills, cut by numerous small stream courses flowing in narrow, winding valleys in a general easterly direction. In the Piedmont section between the Blue Ridge Mountains and the Southwest Range lies a double range of small mountains known as the Ragged Mountains. These begin as a series of low hills near Charlottesville and extend southwest through the area, barely reaching a maximum height of 2,500 feet above sea level.

The Blue Ridge Mountain system extends throughout the area in a northeast and southwest direction, reaching a maximum elevation of a little more than 3,900 feet. It is characterized by its broad, smooth ridges, composed of schist of Algonkian age, flanked on the eastern slope by spurs and sharp knobs of granite, and on the western slope by narrow, ragged ridges and sharp foothills of sandstone and low rounded knobs and gentle slopes of shale of the Cambrian period.

The Great Valley of Virginia occupies the remainder of the area, extending from the Blue Ridge to the Allegheny Mountains. It ranges in elevation from 1,200 feet above tide level to over 1,700 feet on some of the higher hills and ridges, about 1,300 feet being the general average. It is drained by the Shenandoah, North, South, and Middle rivers and their tributaries. In the northern part the valley is divided by Massanutten Mountain into two valleys, known as the Page and Rockingham valleys. In general it is a broad, gently rolling valley. In all 18 different soils were recognized and mapped in this area.

The first soil in order of extent is the Edgemont stony loam, which covers 134,656 acres, or 14.9 per cent of the total area. This occurs as a broad, continuous belt forming the western flank of the Blue Ridge Mountains. The physiographic features consist of sharp peaks and ridges, with either vertical cliffs or steep stony slopes. The ele-

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vation ranges from 1,700 to 3,000 feet. The areas of this soil are so steep and stony that only rarely can they be cultivated, and then only with difficulty. Both the contour and texture of this soil afford thorough and rapid drainage. Most of the type is in forest, but the soil is so thin that it can support only a light growth. There are a few areas free from stones, on which fairly good crops of wheat and corn are grown. Grass is also grown in some of the better areas. This part of the type would probably make good truck soil. Wild grapes grow luxuriantly on this soil, and it may be that the cultivated varieties could be profitably produced on it. It is upon certain exposures and elevation of this soil that the mountain peaches are produced in Maryland.

The Porters sand, another mountain type, covers 115,136 acres, or 12.6 per cent of the area. On the steeper areas there are so many bowlders and outcrops of rock that the soil is of no agricultural value. On the lower slopes and in the depressions the soil is less stony and even loamy. This type occurs in numerous irregular shaped bodies on the spurs and foothills of the Blue Ridge Mountains and the small detached ranges in the Piedmont Plateau. This soil is in general too steep and stony to cultivate, is of practically no agricultural value, and consequently is left in forest. It is valued to some extent for lumber and tanbark. It is only on the smoother and less stony slopes of the foothills and detached ranges that the land is cleared and worked, and even there it can not be considered a desirable soil for general farming. Within the last few years, however, it has been found to be adapted to peaches and small fruits, and this interest is now being developed. On the stony areas, where the soil is quite loamy and deep, Albemarle pippins have been found to do well.

The Cecil loam, one of the Piedmont types, covers 94,592 acres, or 10.5 per cent of the area. It is confined to areas lying between the Blue Ridge Mountains and the Southwest Range. This soil is of residual origin, being derived from the weathering of mica schists. Its surface is rolling to hilly and its drainage good. On account of its rapid and thorough drainage the soil is apt to suffer from drought. This soil is very easily washed, and many of the slopes are so badly gullied that cultivation is impracticable. On this account much of the soil is not cultivated. Of the farm crops the soil is best adapted to corn, which yields from 10 to 30 bushels per acre, the average being about 20 bushels. Wheat yields from 5 to 8 bushels, though larger yields are obtained on the heavier phases of the type. Grass and clover do not succeed well. When this soil extends up the slopes of the foothills it is well adapted to fruit. The red varieties of apples do well on it, and it is also used for peaches, commercial orchards of this fruit now being established on it.

The Cecil clay, another of the Piedmont types, covers 79,680 acres,

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or 8.8 per cent of the area. It is found chiefly upon the uplands of the Piedmont Plateau. Where the areas are near large streams, the formation is hilly, having the characteristic topography of the Piedmont. In places the soil extends up the lower slopes of the Blue Ridge and foothills. It is also found on the top and on the long gentle slopes of the Green Mountains. This soil generally has good surface drainage, though the more level areas could be much improved by artificial drainage. In origin this soil is both residual and sedimentary, being derived from igneous and metamorphic rocks. The Cecil clay is considered the most desirable of the Piedmont soils for general farming. It is a heavy soil, and is best adapted to wheat, tobacco, and grass. It is retentive of moisture and fertilizers, and is capable of being brought to a high state of cultivation. But little tobacco is now grown, owing to scarcity of labor. The yield of wheat will average 8 bushels per acre, but in the better cultivated areas the yield is much higher. Except on the heavier phases, corn does fairly well. The grasses and clovers produce well upon this soil if they are once well established. The red varieties of apples, grapes, and peaches do well on this soil, especially on the Green Mountain area.

The Hagerstown shale loam covers 75,328 acres, or 8.3 per cent of the area. It occurs in all of the physiographic divisions found within the area. The topography of the soil in the valley is characteristic of the shale formations, consisting of a series of hills of uniform elevation and generally smooth contour and gentle slope. In the mountain area the soil forms a series of small mountains or ridges. The topography in the Piedmont area is much like that of the valley. The Hagerstown shale loam is a residual soil, derived from the weathering of shale. It is best adapted to the production of wheat, and is largely devoted to that crop. The average yield is not more than 15 bushels per acre, although in the valley the yield per acre is sometimes as high as 45 bushels. Corn does fairly well in favorable seasons, but usually the soil is too dry for this summer crop. The land is best adapted to those crops which are harvested before dry weather comes, or which can tide over the periods of drought. The rough mountain areas of this soil in the Blue Ridge are considered of so little value that they are not even cleared. In the Piedmont area the soil is mostly forested. When cleared and cultivated, the best of the Piedmont areas will not yield over 10 bushels of wheat per acre. Some of these areas will grow grass. The more sandy and higher lying areas are said to produce excellent fruit, especially peaches, but there are no commercial orchards established on the type at present.

The Porters black loam covers 68,736 acres, or 7.6 per cent of the area. This type occupies the broad, rolling top and the upper slope of the main range of the Blue Ridge Mountains, where it occurs in one continuous area. Small areas are numerous in the foothills and

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detached ranges in the Piedmont Plateau, occurring mostly in the coves. This soil is residual in origin, being derived in the Blue Ridge proper from the weathering of schist. Of all the soils of the area this is preeminently adapted to the production of the Newtown or Albemarle pippin. This soil is not adapted to wheat or corn, as wheat winterkills and the elevation is usually too high for corn. Oats do well, making large yields. Irish potatoes will yield from 200 to 300 bushels per acre and are of excellent quality. The soil is well adapted to grazing, and to that use it is now chiefly devoted. The often remote situation and great elevation make it difficuit to handle the general farm crops. There are numerous orchards on the lower eastern slopes. The western slopes are too much exposed for fruit. In the coves of the Ragged Mountains this soil is considered the best "pippin soil." These coves have a deep soil and an elevation suited to the production of superior fruit. The Albemarle pippin, red winter apples, and all varieties of peaches do well. The forest growth in these coves is the heaviest in the area.

The Hagerstown stony loam covers 59,136 acres, or 6.5 per cent of the area. This soil occupies the higher and steeper ridges of the valley and its natural drainage is good. It has been derived from the weathering of impure or cherty limestone. Wheat and corn are the chief crops grown upon the Hagerstown stony loam. Wheat yields on the average between 10 and 20 bushels to the acre and corn from 20 to 40 bushels. The soil as a rule does not seed readily to grass. It is believed to be adapted to fruit, especially apples and peaches, which have been pronounced by commission men to be of superior quality. Many peach orchards and apple orchards have already been set out on this soil.

The Cecil sandy loam covers 47,808 acres, or 5.2 per cent of the area. The soil occurs chiefly in the Piedmont Plateau, the areas, broken and irregular in shape, occupying the level uplands and extending up the gentle slopes of the foothills and detached ranges to elevations rarely exceeding 800 feet above sea level. The position of this soil affords good surface drainage. The Cecil sandy loam is a residual soil derived from the weathering of granites and other igneous and metamorphic rocks. This soil is desired for general farming only to a limited extent and is largely under forest. It is considered poor and thin, but is capable of easy improvement. Wheat and corn are the chief crops, the former yielding about 8 bushels per acre and the latter from 15 to 25 bushels. Grass does not do well upon this soil. Where this soil occurs on the lower slopes of the foothills it has been found to be adapted to peaches and small fruits, but so far no extensive orchards have been planted except near the railroad.

The Hagerstown sandy loam covers 45,504 acres, or 5 per cent of the area. It occupies some of the higher ridges of the valley, the

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banks of the main river, and the lower slopes of the mountains. Its physiography insures good natural drainage. This type is both residual and colluvial in origin. On the ridges in the valley it has been derived from shaly sandstone occurring in the beds of limestone. The gently rolling areas of this soil near the rivers are desired for general farming. The soil is easy of cultivation and retentive of moisture and fertilizers, making it a comparatively sure soil for crops and one easily improved. Wheat, corn, and grasses are the crops grown. Wheat yields on the average from 15 to 20 bushels per acre and corn from 30 to 50 bushels. Grass and clover do fairly well. On the ridges and lower slopes of the mountains this soil has been found to be especially well adapted to peaches. Several large orchards have proven successful financially.

The Meadow soils of the area cover 40,640 acres, or 4.5 per cent of the total. This term has been applied to a class of soils of recent sedimentary origin, occurring along the larger stream bottoms. The greatest development of Meadow is in the valley, along the Shenandoah River and its tributaries. In the Piedmont section this type is not important. In general, the Meadow lands are wet and poorly drained and are subject to frequent flooding. In the valley they are used mostly for grazing. Back from the streams, where only the highest waters reach, wheat and corn are grown. The soil and moisture conditions are best adapted to corn, which yields often as high as 100 bushels per acre. Wheat makes too rank a growth and is apt to be damaged by floods. These bottom lands produce good melons, and near the larger towns this crop is grown on a commercial scale.

The Porters clay covers 32,512 acres, or 3.6 per cent of the area. It occurs as a nearly continuous belt occupying the lower slope on the eastern side of the Blue Ridge Mountains to Simmons Gap, where it breaks, and is then continued on the western lower slope, passing out of the area. The surface features of this soil type are those of the mountain slopes. On account of its physiographic position this soil has good surface drainage. The Porters clay is a residual soil, derived from the weathering of schist. This soil ranks next to the Porters black loam in fertility and agricultural value of the mountain types. Wheat, corn, and the grasses are the chief crops grown upon it. Because of its location it is much better adapted to grazing than to the cultivated crops. It is now being developed as a fruit soil, especially for apples. The chief objection to it is its steep contour, making it difficult to cultivate and spray the trees and to harvest the fruit.

The Hagerstown loam covers 30,784 acres, or 3.4 per cent of the area. It occurs in two principal areas in the valley, one in the vicinity of Stonewall and the other just west of Waynesboro. Other smaller areas occur throughout the valley. The area in the vicinity of Waynesboro is gently rolling, sloping slightly toward South River,

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and is drained by numerous small streams. The topography of the Stonewall body of this soil consists of a series of high, rolling ridges, the slopes of which are badly washed, a tendency to wash being a property of this type. This soil is easy to cultivate and is well adapted to general farming. Wheat is sown upon it year in and year out, giving an average yield of from 15 to 20 bushels per acre. Corn yields from 40 to 50 bushels per acre. This is preeminently the corn soil of the area. It is not as strong grass land as the heavier soils. Besides the general farm crops, this soil produces fine winter apples. Several large orchards are found upon this type.

The Hagerstown clay covers 25,920 acres, or 2.9 per cent of the area. It occurs in one large irregular-shaped area in the northern part of the valley, and a few small areas lying just southwest of Massanutten Mountain. The surface features partake of those of the valley, and the soil has excellent surface and underdrainage. This soil is of residual origin, being derived from the weathering of pure massive limestone. The Hagerstown clay is the most generally desired of all the valley soils. It is very fertile and produces large crops. It is best adapted to wheat and grass, which are the crops principally grown upon it. Wheat yields on an average about 25 bushels per acre. Generally the land is of too heavy a texture for corn. Large crops of timothy and clover hay are secured. The land is somewhat difficult to work on account of its heavy nature. Lime is beneficial.

The Conestoga clay covers 16,960 acres, or 1.9 per cent of the area. It occurs as long and narrow valley areas, following the general direction of the valley formation. The higher parts of areas of this soil have good surface drainage, but the lower and more level strips need artificial drainage. The Conestoga clay is of residual origin, being derived from a schistose or shaly limestone. This is the heaviest and most intractable of the valley soils, and requires careful treatment to produce good crops. The crops best adapted to the Conestoga clay are wheat and grass. With proper treatment and a favorable season the yield of wheat will average as high as 40 bushels to the acre, and from year to year the yield averages from 25 to 30 bushels per acre. Yields of from 2 to 3 tons of timothy per acre are obtained. Clover also does well.

The Penn clay covers 16,128 acres, or 1.8 per cent of the area. It is derived from fine-grained sedimentary sandstone. Its surface is gently rolling. This soil is practically all cleared and under cultivation. It produces on an average between 10 and 15 bushels of wheat per acre, though yields as high as 45 bushels per acre have been obtained. Corn yields from 30 to 60 bushels per acre. It is an excellent soil for grass.

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The Conowingo barrens cover 6,976 acres, or 0.8 per cent of the area. This soil occurs in the Piedmont Plateau, forming a continuous strip from one-fourth mile to 1 mile wide, occupying a ridge extending from the northeast corner of the Buckingham sheet southwest through the area. This soil is derived from the weathering of serpentine and similar altered rocks. The land is worthless for agricultural purposes, being quite unproductive, and none of it is under cultivation.

The Conowingo clay covers 6,272 acres, or 0.7 per cent of the area. This is a Piedmont soil and occupies a ridge parallel to that covered by the Conowingo barrens. It is derived from the weathering of steatite and other metamorphic rocks. It is a productive soil, readily improved, and when brought to a high state of cultivation is easily kept there. It is a good corn soil, yielding 20 bushels or more per acre. The yield of wheat will probably not average over 8 bushels. The grasses and clover do fairly well upon it.

The Penn sandy loam covers 5,568 acres, or 0.6 per cent of the area. It occupies gently rolling or nearly level uplands. The higher parts have good natural drainage, but near the heads of the streams the areas are nearly level and drainage is slow and artificial drainage is necessary before the land can be cultivated successfully. The Penn sandy loam is a residual soil, derived from the weathering of a brown or red sandstone. The greater part of this soil is in forest and is not generally desired for cultivation, only the better parts being farmed. Wheat and corn are the crops raised on it, the yields being about the same as on the Cecil sandy loam.

Fruit growing has become an important part of the agriculture of the Albermarle area, the favorable climatic conditions and the number of soils adapted to the different varieties of fruits making this an area peculiarly adapted to successful fruit growing. The principal development of this industry has been in the southern part of Albemarle County, extending over into Nelson County. There are probably 800,000 apple and 100,000 peach trees of bearing age in this section. The fruit interest east of the Blue Ridge is developed principally in two sections. One occupies the lower eastern slope of the Blue Ridge, from near Crozet to Humpback, and the other and larger section is in the Ragged Mountains, where the orchards are mostly in the coves. There are also orchards scattered throughout the plateau proper. In the valley the planting of orchards has been general, especially on the lighter soils. The orchards now bearing are peach, apple orchards having only recently been set out. Most of the orchards on the eastern slope of the Blue Ridge are located in what is known as the "green belt," a frostless zone lying between elevations of 1,000 and 2,000 feet above sea level. This region is free from frosts, heavy storms, and fogs, and is famous for its Albemarle pippins, which

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thrive especially well on the Porters black loam, sometimes called "pippin land." The red varieties of apples, including Winesap, York Imperial, Pilot, Ben Davis, Baldwin, and others, are also grown and yield profitable crops. Peaches do well, the leading varieties grown being the Belyeu Comet, Elberta, and Crawford. Grapes are grown successfully, but owing to competition from northern growers few table grapes are produced, the industry being confined almost exclusively to the wine-making varieties.

As a whole the farming class in this area is prosperous. The Valley of Virginia has always been recognized as the most prosperous section of the State, due to the natural fertility of its soils and the thriftiness of its people. The average size of the valley farms is from 200 to 250 acres, and the largest seldom exceed 400 acres. Most of them are owned by the farmers who operate them. Labor here is scarce, but is efficient. The negro population is small. Improved machinery is used upon all the valley farms. Growing grain and hay and raising live stock are the principal industries, but the fruit industry is being rapidly developed in the valley, especially on the lighter and poorer soils.

Much of the mountain area is of little value except for its chestnut and oak timber. The mountain lands so located as to be adapted to pasturage or fruit are in demand and bring fair prices. The coolness and absence of flies in the higher elevations make these lands desirable for pasturing stock.

The Piedmont section of the area is not so prosperous as the valley, but conditions are improving. The farms in this section are all large, usually averaging 300 acres, and there are a number containing from 500 to 1,000 or more acres. As a rule the owners live upon their farms, working all the land they can with the labor that can be hired and letting out other tracts to tenants. Only the better parts of these large farms are cultivated, the remainder being left uncultivated and allowed to wash and gully. Labor is scarce and inefficient. Much of the negro labor has left the area for work in the towns and cities. More care should be taken to prevent washing of the land, and more of it should be put in pasture.

HICKORY AREA, NORTH CAROLINA.

The Hickory area has an extent of 987 square miles, or 632,128 acres. It lies in the Piedmont Plateau and includes parts of Catawba, Burke, Caldwell, Alexander, and Iredell counties. Hickory is the largest town, with a population of over 2,000. Other towns are Newton, Maiden, Catawba, and Taylorsville. The Brushy Mountains cross the northwest corner of the area, forming a divide between the drainage systems of the Yadkin and Catawba rivers. The elevation ranges from 700 feet above sea, where the Catawba River leaves the area, to 2,430 feet in the highest knob of the Brushy Mountains. The soils

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are chiefly derived from granite, gneiss, and schists. In the rolling plateau country these have weathered to great depths, and the soil mantle is correspondingly deep. In the southeastern part of the area, lying within the Kings Mountain belt, the rocks are quartzites, clay slates, and mica schists. Some beds of limestone also occur in that section.

The principal crops of the area are cotton, wheat, and corn. Cotton can not be grown successfully in or near the mountains, as the season is too short. A considerable interest in the production of sweet potatoes for outside markets is developing on the Cecil sandy loam near Hickory, 110 carloads having been shipped from that place in 1901.

The Cecil sandy loam, covering 355,968 acres, or 56.4 per cent of the area, has the widest distribution of any of the soils of this survey. It is a light, easily cultivated, and well-drained soil, and is used for cotton, corn, wheat, and sweet potatoes. Cotton yields about one-half bale on the average, though with best cultivation 1 bale can be produced. The average yield per acre of corn ranges between 25 and 35 bushels and of wheat is about 12 bushels. Sweet potatoes yield as high as 350 bushels per acre, with the average not far from 200 bushels. The soil seems well adapted to cotton (except near the mountains), sweet potatoes, and vegetables. It requires careful treatment to bring out its capabilities.

The Cecil clay is the second in extent of the soils of the area, covering 120,704 acres, or 19.1 per cent. It is confined to the Piedmont Plateau and occurs chiefly in a continuous body reaching northeast and southwest of Reepsville. It is considered one of the most fertile soils of the area and well adapted to all farm crops. It is probably best adapted to wheat, which yields an average of 20 bushels to the acre, 40 bushels on the best-cultivated farms being a not uncommon yield. Under best conditions 1 bale of cotton can be produced, but the average is about one-half bale per acre. Corn is also an important crop. Cowpeas are extensively grown as fodder and for green manuring.

The Porters sandy loam, covering 49,920 acres, or 7.8 per cent of the area, occupies mountain tops and slopes and the high rolling areas between the mountains and the Piedmont Plateau proper. It is derived from the same rocks as the Cecil sandy loam. Its elevation unfits it for cotton cultivation. Wheat, corn, oats, rye, sweet and Irish potatoes, and fruits are the principal crops.

The Conowingo clay, covering 29,952 acres, or 4.6 per cent of the area, occurs as a long irregular belt, often 4 or 5 miles wide, in the Brushy Mountains. This soil is derived from a red talc schist. It is well drained, but care must be taken to prevent washing. The soil is much improved by deep plowing, the yield of wheat being increased by such practice from 10 bushels, about the average, to 18 bushels. Corn

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yields from 12 to 15 bushels per acre; oats about 15 bushels. Areas of this soil lie too near the mountains to allow the successful culture of cotton. It is upon this soil that the colony at Valdese, near Morganton, has so successfully introduced grape culture. This indicates clearly the practicability of introducing a new and profitable industry into the Hickory area.

The Porters stony loam, covering 25,152 acres, or 4 per cent of the area, is a mountain type representing a condition rather than a soil of definite textural characteristics. It includes all land too rocky for cultivation, although within such areas there are here and there small patches where by picking off the stones the land has been converted to agricultural use. Such areas are best adapted to fruit—apples, peaches, and grapes. One of the successful apple growers in the Little Brushy Mountains makes use of this soil, building stone walls across the narrow ravines and setting a tree just above each wall. The fine sediments are thus collected and held around the roots of the tree and a moisture condition maintained essential to rapid and vigorous growth. On Barrett Mountain some of the best peach orchards in the area are grown upon this soil type. Many areas still support valuable hard-wood forests.

The Meadow, covering 23,872 acres, or 3.8 per cent of the area, consists of bottom soils of heterogeneous composition and subject to overflow. Where cultivable it forms one of the valuable soils of the area. Many of the areas have been thrown out of cultivation in recent years by the increase in the number and violence of the freshets. The stream channels are silting up with the wash from cultivated fields and deforested mountains. The Meadow is often ruined by the deposition of barren white sand.

The Porters sand, covering 11,136 acres, or 1.8 per cent of the area, is another of the mountain soils. It is considered rather a poor soil for agriculture, is stony, and washes badly. The greater part of the area of this type is still in forest. In favored situations peaches do well upon it.

Porters clay, covering 7,552 acres, or 1.2 per cent of the area surveyed, is, next to the bottom lands, recognized as the strongest soil found in the mountainous part of the area. In characteristics, derivation, fertility, productiveness, and crop adaptation it closely resembles the Cecil clay—the red land of the Piedmont Plateau. Within the mountains the Porters clay occurs in all situations, from the intervening valleys to the mountain tops. In the former situations the soil has a tendency to bake badly, and in this respect suffers in comparison with the Cecil clay. Wheat yields about 15 bushels and corn 18 bushels per acre, but these yields can be greatly exceeded by more careful cultivation. Oats do well. The soil is best adapted to wheat and apples.

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The Durham sandy loam, covering 7,360 acres, or 1.2 per cent of the area, occurs in the Piedmont Plateau in the vicinity of Rocky Springs. It is esteemed a poor soil in the Hickory area, probably because it is not very productive when used for cotton and corn. It will produce readily 200 bushels of sweet potatoes to the acre, but no attempt to supply outside markets has been made. The soil is also adapted to other truck crops. It is a typical bright-tobacco soil, but none is now grown. It is difficult to maintain the fertility of this type on account of its open and leachy nature.

The Porters black loam, covering 512 acres, or 0.1 per cent of the area, is an important mountain soil occurring throughout the Appalachian system. It is the typical apple soil of the Virginia Blue Ridge country and is being rapidly developed in the production of this fruit. There is so little of it, however, in the Hickory area that it has practically no influence on the local agriculture.

MOUNT MITCHELL AREA, NORTH CAROLINA.

The area surveyed lies in the northwestern part of North Carolina, bordering on Tennessee, and includes most of Yancy and Mitchell counties and parts of Madison, Buncombe, and McDowell counties. The area contains about 500 square miles, and is located in the highest part of the United States east of the Rocky Mountains.

This area is situated in the great plateau lying between the Blue Ridge on the east and the Smoky Mountains on the west. This plateau has an average altitude of about 3,000 feet, and is crossed by numerous chains of mountains, extending at right angles to the general trend of the Appalachian system, which rise in some instances to over 3,000 feet above the plateau itself. Mount Mitchell, the highest peak in the United States east of the Rocky Mountains, is included within this area. It has an elevation of 6,711 feet above tide. The lowest point in the area is on the North Fork of the Catawba River, at the foot of the Blue Ridge Mountains, and is 1,350 feet above tide water. On the plateau the cross chains are sometimes broken down, but there are no broad and well-defined valleys. The region is, of course, well drained. The rocks of the area belong to the various granites, gneisses, and schists. These rocks disintegrate very rapidly, and the steep mountain slopes and tops of the highest mountains are usually covered with a deep soil.

The Porters clay, the soil of greatest extent in the area, covers 98,624 acres, or 31 per cent of the total. This is a residual soil derived from the weathering of granite, gneiss, and schist rocks. It is not confined to any particular part of the area, but the largest bodies of it are found in those sections which lie between the higher mountain ranges and the low and rounded ridges. It is also found along the foothills of the higher mountains, and often extends up the southern

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slope of these a considerable distance. This is one of the most desirable soils in the mountains for general agricultural purposes. The principal crops are corn, grass, fruits, and wheat, in addition to which are grown sorghum, Irish and sweet potatoes, and vegetables. Corn yields about 20 bushels per acre, wheat about 10 bushels, oats about 30 bushels, and sweet and Irish potatoes about 200 bushels. This soil is capable of a high state of improvement and retains fertilizers for a long time. Upon this type some of the best apple orchards in the area are growing.

The Porters black loam covers 87,808 acres, or 27.6 per cent of the area. It is found on all the high mountains, especially on those which have never been cleared. Where cleared, the soil is apt to wash badly, sometimes being entirely removed and exposing the underlying red clay. It is well drained. Ordinarily its fertility is easily maintained, nor does the surface wash, but by improper methods of cultivation it has in a few places been badly washed. The fertility and loose texture of this soil seem to adapt it especially to Irish potatoes. It is also well adapted to corn, where found low enough to furnish proper climatic conditions for that crop, and also to timothy and clover. It is especially well adapted to vegetables. In the lower altitudes the possibilities of this soil for fruit, especially apples, are being recognized.

The Porters sandy loam covers 76,480 acres, or 24.1 per cent of the total area. It is derived from the weathering of granite, gneiss, and schist rocks, and is found in one large body in the northern part of the area and in small patches throughout the area, except on the higher mountains. This soil is well drained, and is subject to washing and gullying. Corn, wheat, oats, sorghum, fruits, and vegetables are the crops principally grown. The average yield per acre of corn is about 25 bushels, of oats, about 30 bushels, and of wheat, about 8 bushels. Sweet and Irish potatoes, where given the best cultivation, yield over 200 bushels per acre. This soil does not retain fertility long, owing to its porous subsoil, and to keep it in a high state of productiveness requires constant applications of fertilizers.

The Porters sand covers 42,816 acres, or 13.5 per cent of the total area surveyed. This soil occurs in several parts of the area, but is found most frequently in the belt of mica-bearing rocks. There are two large areas of this type, one on the Toe River, northeast of Burnsville, and the other in the vicinity of Sprucepine, extending northward toward Yellow Mountain. The type is formed mostly from the large individual particles of feldspar, quartz, and mica in the pegmatite granite. The considerable admixture of mica found in Porters sand causes it to be regarded as a poor soil, but with proper cultivation and fertilization nearly all of the general crops of the mountains do fairly well. Corn, oats, fruit, and vegetables are grown. Corn yields on an average 15 bushels per acre and oats about 20 bushels.

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No wheat is grown on this soil. Cherries and peaches do exceedingly well. Some areas of this soil are used for pasturage, and it is said to support a very good growth of grass.

There are 6,976 acres of Meadow, comprising 2.2 per cent of the area. It is always found along the stream courses. Where the valleys are wide the Meadow is the most valuable soil in the area, in some places having been sold for as much as $100 per acre. It is well adapted to all the crops of the area, but is especially valuable as a corn and grass soil. As high as 80 bushels of corn have been produced upon it, and 1½ tons of hay per acre is not an uncommon yield.

In addition to the soils already described there were found in the area 5,184 acres, or 1.6 per cent, of rock outcrop, upon which no soil was present, or so stony as to be entirely unfit for cultivation.

The agricultural development of this region has been held in check by the lack of transportation facilities. Since railroads have come nearer, markets have opened up and farming has received a great stimulus. All the fruits and vegetables suited to such a climate grow luxuriantly. None of the land above an altitude of 3,500 feet has ever been cultivated, and as to the possibilities of cultivation above that height nothing is known at present.

ABBEVILLE AREA, SOUTH CAROLINA.

The Abbeville area comprises 1,006 square miles, or 644,160 acres, and includes parts of Abbeville, Greenwood, Laurens, and Anderson counties. The area lies in the Piedmont Plateau, has a gently undulating, plainlike surface, becoming more rolling or even broken near the streams, and ranges in elevation from 570 to 657 feet above sea level. The area is well drained by two river systems, separated by a divide extending southeast from Honeapath to Ninetysix. The rivers furnish abundant water power and many gristmills are found. At Ware Shoals, on the Saluda River, there is a fall of 68 feet in 3 miles, and plans are about completed for the erection of a $500,000 cotton mill to utilize a part of the immense power now going to waste.

The general size of the farms ranges from 300 to 500 acres, although there are some tracts of 3,000 and 4,000 acres. These are gradually being subdivided and sold. In the vicinity of the towns many of the owners reside on and till their own farms. In more remote parts of the area the proportion of tenants is greater. Where not worked on shares, the average rental is 2 bales of cotton for 30 acres; where worked on shares, the landlord furnishing all necessaries except subsistence, one-half the crop is reserved. Negro labor is the main dependence.

Cotton is the one great product. Formerly the grains were more important, but the cultivation of cotton has both crowded out those products and exhausted the soil so much that a resumption of their

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profitable culture is impracticable, except through a slow and expensive system of soil preparation extending over a series of years. Railroad facilities are fairly good.

The Cecil clay, covering 332,992 acres, or 51.7 per cent of the area, is the characteristic red clay land of the Piedmont Plateau. It is the prevailing type in the southern part of the area, extending back for 2 or 3 miles on each side of the stream courses. It is the strongest and most productive soil in the area, producing from 200 to 250 pounds of cotton, 15 to 20 bushels of corn, 8 to 12 bushels of wheat, and 18 to 24 bushels of oats per acre.

The Cecil sandy loam, covering 236,238 acres, or 36.7 per cent of the area, is the prevailing soil in the northern part, though found throughout the area. It usually occupies level areas and ridges. It is sometimes preferred to the Cecil clay because of greater ease of cultivation, but the yields are somewhat less than on the heavier soil. Cotton gives a yield per acre ranging from 175 to 225 pounds of lint, corn from 8 to 12 bushels, and oats about 15 bushels. Peaches, plums, cherries, and apples grow well on this soil. Truck and tobacco would do well.

The Durham sandy loam, covering 27,840 acres, or 4.3 per cent of the area, is the sandiest type of the area. It occurs in two large bodies—one around Hodges and the other in the vicinity of Craytonville—and many areas of small extent. This type is generally confined to the higher areas, near the upper courses of streams. It is used at present almost exclusively for cotton and corn. Cotton yields about 200 pounds, and corn 10 bushels per acre. It is an excellent soil for sweet potatoes and cowpeas. It produces fine grapes, and certain gravelly areas have a special adaptation for pears. It is a typical melon and bright-tobacco soil.

The Davie clay loam, covering 25,856 acres, or 4 per cent of the area, is found in long, narrow belts in the southern part of the area. It is derived from outcrops of talc schists and talcose slates. The soil has about the same value for cotton and other crops grown as the Cecil sandy loam.

The Iredell clay loam, covering 14,848 acres, or 2.3 per cent of the area, consists of a thin covering of 6 to 8 inches of loam underlain by a stiff, tenacious, waxy clay. The drainage is naturally poor and cultivation difficult, for which reasons little use has been made of this type. Cotton has a tendency to rust on it. It is best adapted to grain and grass.

The Meadow, covering 6,336 acres, or 1 per cent of the area, occurs along all the streams. The soil is deep, fertile, and very productive. The chief drawback is liability to overflow, which is said to be increasing. Corn yields about 40 bushels to the acre. The Meadow also furnishes excellent pasture.

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The adaptation of soils to crops has been given but little thought in this area. Cotton is grown on both heavy and sandy soils indiscriminately. The latter seem well adapted to small fruit and truck. There should be opportunity for the introduction of new industries in this area, looking toward supplying early vegetables and small fruits to Northern markets. The red clay soil is particularly subject to washing. Where cleared land is neglected, gullies 20 to 30 feet deep are often seen. More care is taken to prevent the ruin of the fields in this way than formerly, the usual practice being to terrace the fields, or, where the slope is slight, to control the removal of the rain water by sidehill ditches.

DARLINGTON AREA, SOUTH CAROLINA.

The Darlington includes all of Washington County and a part of Lee County. It lies northeast of the center of the State, has an area of about 600 square miles. Darlington, the county seat of Washington County, is the largest town, and has a population of over 5,000. The area lies wholly within the Coastal Plain. The Pedee River drains the larger part of the area, and Lynchs River the remainder. There are three physiographic divisions: The bottom lands along the Pedee and, to a less extent, Lynchs River, the large central part occupied by the gently rolling plateau of the upland, and the northern and western area occupied by ranges of hills covered mainly by loose, leachy sand.

Ten years ago cotton was the one leading crop of the Darlington area, but now the annual value of tobacco has nearly reached that of cotton. These two products are the mainstay of the agriculture of the area, nearly all the other crops being incidental to the production of these staples. Not enough corn is grown in the area to supply the local needs, and there is room for further extension of this and other fodder crops and the introduction of a still more diversified system of agriculture.

Probably not more than one-third of the farms in the county are tilled by the owners, the bulk of the remainder being farmed by negro tenants on the share system. The average size of farms is about 70 acres, although there are several plantations of 1,000 acres or more. The tendency is undoubtedly toward smaller holdings and personal operation. The labor question is becoming more serious from year to year as the negroes are attracted to the towns, where higher wages and shorter hours are the rule.

Although tobacco has been grown in the county but a few years, the methods are equal to the best in the areas where longer established. The adaptation of soils to this crop has been worked out experimentally and is generally well known. There is, however, room for more scientific methods of cultivation and curing of the

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tobacco, thereby raising the standard of quality and the profit to the grower. Excepting in the case of tobacco, soil adaptation has not been given much consideration. Ten distinct types of soil were recognized in the county.

The most extensive type is the Goldsboro compact sandy loam, occupying 118,208 acres, or 30.8 per cent of the area surveyed. This type is well distributed over the central and southern part of the county, large areas lying between Darlington and Hartsville. It occupies flat, level stretches of the upland, and in places the drainage is poor as a result of this surface configuration. Large tracts of this type which were formerly covered with standing water during rainy seasons have been reclaimed by the use of shallow ditches. The soil supports a natural growth of pine, oak, and hickory, and, in poorly drained areas, of black and sweet gum. The greater part of the cultivated areas are devoted to cotton and corn. The average yield of the former is about one-half bale to the acre. The soil is too heavy for bright tobacco.

The Norfolk sand, covering 71,104 acres, or 18.5 per cent of the area, is the typical truck soil of the Atlantic seaboard, but it is not used for this purpose in this area. Light yields of cotton and corn are obtained, and a fair quality of tobacco is produced, but it is not regarded as the best soil for this crop.

The Norfolk sandy soil, covering 65,024 acres, or 17 per cent of the area, occurs as borders from one-half to 2 miles wide along the smaller streams. The drainage of this type is perfect. It is the bright-tobacco soil of the area, producing the bulk of the crop, although some other soils produce a little better quality of leaf. The soil will yield from 700 to 1,200 pounds per acre, but the best growers do not care to force the yield above 1,000 pounds, as the increase of weight is made at the expense of quality. The price for the leaf ranges from 5 to 65 cents a pound, according to quality, the average being about 10 cents. Cotton yields an average of one-half bale per acre.

The Sandhill, covering 30,656 acres, or 8 per cent of the area, extends from Greenplain to Clyde in an almost unbroken area 12 miles long and 5½ miles wide. The topography consists of a series of long, high ridges or hills. The natural vegetation is a sparse growth of pine and scrub oak. The soil is leachy, and attempts to cultivate it have met with little success.

The Sassafras loam, covering 26,880 acres, or 7 per cent of the area, extends as a broad belt along the Pedee River, and has a maximum width of more than 5 miles within the bend of the river known as Robbins Neck. This type occupies a series of terraces, the lowest of which is frequently flooded. During slavery days these areas were protected by dikes, but they have been destroyed from time to time and not replaced. This type is well adapted to corn and wheat, but

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its possibilities have not been realized. Only a few square miles of this soil about Robbins Neck are under cultivation, the remainder being covered by a dense forest of valuable timber.

The Ayden fine sandy loam, covering 25,600 acres, or nearly 7 per cent of the area, occupies sometimes level and sometimes rolling areas, and varies slightly in texture and agricultural value. The soil retains organic matter and other fertilizing elements well, and when properly cultivated is recognized as the best cotton soil in the county, yielding on an average three-fourths of a bale per acre. Corn yields 35 bushels per acre. Cotton and tobacco are the principal crops. On a few small areas of a phase of this soil type is produced the finest type of bright tobacco grown in the county.

The Selma heavy silt loam, covering 15,488 acres, or 4 per cent of the area surveyed, is typically developed in long, irregular, depressed areas, where the natural drainage is imperfect. Much of this land may be reclaimed by artificial drainage, but some areas prove worthless even after drainage, because of the compact, lifeless character of the soil. The greater part of this soil is under heavy forests, but where cultivated about one-half bale of cotton to the acre is produced.

The Swamp area covers 14,144 acres, or 3.7 per cent of the county. The areas lie along Lynchs River and some of the smaller streams, and are more or less under water the greater part of the year. No attempt has been made to reclaim and cultivate any of this land, and it is now covered by an almost impenetrable forest.

The Orangeburg sandy loam, covering 9,984 acres, or 2.6 per cent of the area surveyed, is at present an unimportant soil agriculturally, the greater part being still covered with a heavy forest growth. The areas have the same topography as the Sandhill, and when cleared the steeper slopes wash very severely. Small yields of cotton and corn are secured from the more level tracts.

The Orangeburg loam, covering 6,592 acres, or 1.7 per cent of the area surveyed, is one of the strongest soils in the Darlington area. The most extensive area lies around Ashland. Lands of this type are highly esteemed, bringing from $40 to $60 per acre. Cotton, corn, and oats are the chief crops. Cotton under good methods of cultivation will yield 1 bale and oats about 30 bushels per acre.

PERRY COUNTY AREA, ALABAMA.

Perry County is situated in the central western part of Alabama, and contains about 762 square miles, or 487,744 acres. The Cahaba River flows through the county from north to south, and is bordered by broad bottoms and terraces. The county is divided into two main physiographic divisions; one known as the uplands and the other as the prairie region. Between them is the Eutaw escarpment, making a distinct line of demarcation. The prairie region pre-

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sents little variation of topography, being level, or nearly so. The prairies cover the whole of the southern and southwestern parts of the area. Throughout the uplands occur long, narrow divides. The country is gently rolling along these divides, but between them the ravines are often deep and steep sided, and along some of the streams even precipitous. The general slope of the surface and the drainage of the country is toward the south. Perry County lies wholly within the Coastal Plain.

There are six types of soil in Perry County, the most extensive being the Orangeburg sandy loam. This soil covers 196,288 acres, or 40.2 per cent of the area. It occurs to the north of the Eutaw escarpment and occupies the rolling country. It is not usually well protected by vegetation or position from the effects of the severe rains, and the areas are very generally washed. The Orangeburg sandy loam is used for cotton production to the general exclusion of other products except corn. The average yield of cotton is about one-third of a bale to the acre. Corn will yield from 10 to 20 bushels to the acre. Wheat can not be grown successfully on account of rust. This soil is well adapted to the truck crops as well as to Kieffer pears, peaches, and some varieties of grapes.

The Houston clay, covering 136,128 acres, or 28 per cent of the area, is one of the prairie soils lying south of the Eutaw escarpment. This soil owes its origin to a Cretaceous sediment laid down in a rapidly deepening sea. The soil cracks in the summer heat, is very plastic when wet, and is difficult to work. It is used largely for the production of cotton. In a favorable season it yields from one-half bale to a bale per acre, but this yield can be counted on only about once in five years. The soil is admirably adapted to stock raising. Johnson grass, a drought-resisting crop, yields an average of about 1½ tons of hay to the acre. Oats and corn do well. Corn yields from 25 to 30 bushels and oats from 25 to 40 bushels to the acre. Wheat rusts badly and is not much grown.

The Orangeburg clay covers 82,752 acres, or 17 per cent of the area. The most extensive areas occur between Oakmulgee Creek and the Cahaba River, north of Perryville, and isolated areas are found throughout the Orangeburg sandy loam. The soil is subject to severe washing and is deficient in organic matter. It is used almost entirely for the production of cotton, of which it yields from 800 to 1,500 pounds of seed cotton to the acre. The yield per acre of corn varies from 10 to 20 bushels. Wheat and oats are successfully grown. This is the only soil in the area upon which wheat does not suffer from rust. Grapes, peaches, and apples are grown to a limited extent for home consumption. The quality of the fruit is good.

The Meadow soils of the area cover 53,696 acres, or 11 per cent of the area. They consist of low-lying and poorly drained tracts found

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chiefly along the Cahaba River, usually occupying the first and second terraces and subject to overflow. In favorable seasons this soil is the most productive cotton land in the area, yielding with little or no fertilization from three-fourths to 1 bale per acre.

The Sassafras sandy loam covers 14,720 acres, or 3 per cent of the area. It occurs along the second bottoms of the Cahaba River and in parts of the bottoms bordering Oakmulgee Creek. Its surface is level or gently rolling, and the areas lie between the first bottom and the rolling country in narrow bands. The soil is very easy to work, but careful management is required to maintain its fertility, as the effects of fertilizers are of only temporary benefit. It is well drained during the summer, but wet and spongy in winter. Cotton is the chief crop produced on this soil, the yield per acre ranging from one-third to one-half bale. Corn yields from 15 to 25 bushels per acre. This soil is much better adapted to truck crops than to any others.

The Norfolk sand covers 4,160 acres, or 0.8 per cent of the area. It produces cotton of better lint than any of the other soils of the county, but the yield is very low, a bale to 6 acres being considered a good average. The soil is best adapted to the production of early truck, but the industry is as yet practically undeveloped.

In the prairie region not over one-third of the land owners live on and till their land. In the hill country probably three-fifths of the farms are occupied by the owners. About one-third of the prairie is rented to white tenants, of whom probably three-fourths pay a stated cash rental, while the remainder work on shares. The amount of land owned by the negroes is less than 5 per cent. The farms vary much in size, about 5 per cent of the area being included in farms of from 80 to 160 acres, 55 per cent in plantations of 160 to 800 acres, and 40 per cent in plantations of 800 to 1,500 acres.

Perry County offers fine opportunities for the development of agricultural industries. At present the local methods are often crude and in most cases inefficient. There is need for greater care to prevent the washing of soils and to preserve their fertility. Deeper plowing and more careful cultivation are recommended. The production of cotton year after year on the same fields has more or less exhausted all the lands. The soils generally are deficient in organic matter, a condition which could be alleviated greatly by the use of green manures. Nearly all of the legumes do well upon the clay soils of the area, while upon the more sandy types cowpeas and the California bur clover are successful soil renovators. Many farmers would find it to their advantage to produce more of the subsistence crops, both for themselves and for the work stock, and to make cotton the money crop instead of the sole crop. Large shipments of corn are now brought into the county. This and other imported agricultural products could and should be produced within the area.

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SMEDES AREA, MISSISSIPPI.

The Smedes area adjoins on the south the Yazoo area surveyed in 1901. It is 52 miles long east and west, the western part being 18 miles wide north and south and the eastern part 6 miles wide. Parts of Yazoo, Madison, Issaquena, and Sharkey counties are comprised within the area.

The Smedes area consists of two distinct physiographic divisions—the Mississippi River flood plain or "delta" and the upland or "hill country." The delta lies about 100 feet above the level of the Gulf of Mexico and the hill country about 250 feet above the delta. The upland is separated from the delta by a sharp escarpment ranging from 150 to 300 feet high. Within this area the delta is about 30 miles wide from the river to the upland and has a flat surface with variations in elevation of not over 20 feet. The higher elevations of the delta occur next to the river and drainage courses.

The upland within the area extends for a distance of about 20 miles from the delta. It is divided into two distinct areas, known as the "Cane Hills" and the "Flat Hills." The area of the Cane Hills extends back from the delta about 6 miles. All the rest of the upland consists of the Flat Hills. The Cane Hills area consists of narrow, steep-sided ridges and cross ridges, flanked by deep V-shaped gullies and stream valleys. Only about one-fifth of this area, consisting of the tops of the ridges and some of the narrow stream bottoms, can be cultivated. The balance of the area is in forest. In the Flat Hills area erosion has not been so heavy and the depth of the stream valleys is less. About two-fifths of the surface of this area is now cultivated.

The Sharkey clay, the first soil in the area in order of extent, covers 149,440 acres, or 50.5 per cent of the total area surveyed. It is a low, wet soil, subject to frequent overflow, and covered with standing water usually until the 1st of June. It occurs in large, irregular tracts in the interstream areas of the delta, and is at present the least important soil of the area from an agricultural standpoint, little if any of it being under cultivation. The soil is covered with a heavy growth of forest. It is a very fertile soil, and with a proper system of levees and drains much of it could be brought under cultivation and made to produce good crops. The cost of such reclamation would be very great, however, and the work so extensive as to be beyond private means. This is a work for the State or for some corporation with great resources.

The Memphis silt loam covers 52,288 acres, or 17.8 per cent of the area. This is an upland soil, being found in both the Cane Hills and the Flat Hills. In the Cane Hills the surface of the Memphis silt loam is made up of steep V-shaped gullies and stream valleys, between which hundreds of very narrow ridges and cross ridges rise to a

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height of from 50 to 150 feet. (See Pl. XVIII.) Only about 15 or 20 per cent of the soil here is cultivated, the fields being mostly limited to the tops of the ridges, because the hillsides wash so badly when cleared. The greater part of the soil in this region is covered with a growth of timber, most of it valuable. In the Flat Hills the Memphis silt loam presents a surface only moderately hilly, and a larger proportion of the soil, possibly 35 or 40 per cent, is under cultivation. The texture and physiographic position of the Memphis silt loam makes it subject to extremely severe washing. The surface drainage is good, but percolation is not rapid and the soil retains moisture well. This soil is derived by weathering of the unconsolidated yellow silt or loess covering the entire upland area. The soil is not as rich in organic matter as the delta soils. The principal crop is cotton. Some corn, cowpeas, and grass are grown for feed for work stock. Vegetables are grown for home use. The yield per acre of cotton ranges from one-half to three-fourths bale, and of corn from 10 to 25 bushels.

The Yazoo clay covers 37,760 acres, or 12.8 per cent of the area. It occupies the low-lying border of the front lands of the streams. Its surface is generally quite flat, and this in connection with the close texture results in imperfect drainage. Open ditches are used to give better drainage. The Yazoo clay owes its origin to deposition in comparatively still water. It is a fertile, productive soil, well suited to the growing of cotton, which is the chief crop on this soil. The average yield is about 1 bale, but where extra care has been practiced yields of 2 bales to the acre have been obtained. Corn yields from 20 to 40 bushels. Good crops of crab grass, Bermuda grass, and cowpeas are secured. The Yazoo clay is now one of the most productive soils of the delta region, with possibilities of further improvement, which will make it more productive and valuable than it now is.

The Yazoo loam covers 20,288 acres, or 6.8 per cent of the area. It occurs as narrow bands along streams, lakes, bayous, and drainage ways. Its surface often has a gentle slope from the stream toward the back lands. It is a fertile soil and yields good crops of cotton every year, the yield ranging from three-fourths bale to 1 bale. Corn yields from 20 to 40 bushels. Along the larger waterways the greater part of the type is cleared and under cultivation, but along the smaller streams and drainage ways much of the land still retains its original forest growth. On the whole, the Yazoo loam is one of the choice soils of the area.

The Meadow type of this area covers 17,408 acres, or 5.8 per cent. Its greatest expanse occurs along the Big Black River, while smaller areas occupy the small, narrow stream bottoms in the upland area. The Meadow areas are flat, low-lying, and wet, and by reason of their location are subject to overflow. When the streams are at their normal stage the drainage of this type is good. These areas have been

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formed by sediments deposited by the streams. Cotton and corn are the principal crops grown on this soil. The yield per acre of cotton averages 1 bale, while corn averages about 30 bushels. Grass and other forage crops do well. Excepting the large area along the Big Black River, most of the type is cleared and cultivated.

The Lintonia loam covers 10,368 acres, or 3.5 per cent of the area. This soil occurs as a strip about three-fourths mile wide skirting the bluff separating the delta from the upland along the Yazoo River and as a well-marked second terrace along the Big Black River. The soil is rarely overflowed. The even surface and unbroken slope make the surface drainage very thorough. This type originated from the transportation of the loess of the bluffs and uplands, principally the former, by erosion. The chief crop of the Lintonia loam is cotton, of which the yield per acre ranges from three-fourths bale to over 1½ bales, with an average of about 1 bale. Good yields of corn, cane, and grass are also secured. The various truck crops and small fruits do well. Peaches, plums, and pears are grown to some extent and seem to thrive. Nearly all of the type is cleared and under cultivation.

The Yazoo sandy loam covers 8,512 acres, or 2.8 per cent of the area. It occurs in narrow bands or ridges along the rivers, streams, and drainage ways. Owing to its texture and location, the Yazoo sandy loam is naturally well drained. This soil owes its origin to deposition. It is fertile and easily cultivated. Cotton yields from one-half bale to three-fourths bale per acre, and with careful cultivation 1 bale per acre can be secured. Corn yields from 10 to 25 bushels per acre. Fair yields of crab-grass hay and cowpeas are obtained. Truck crops grown in a small way for home supply do well. The type is almost all cleared and under some form of cultivation. It is believed this would make an excellent early-truck soil.

The farmers of the Smedes area consist of whites and negroes, in the proportion of about 1 to 9 in the delta and 2 to 3 in the upland. As a class the negroes are shiftless and improvident, but there are some notable exceptions. Most of them are tenants. The white farmers usually own their lands, and as a whole are in a fairly prosperous condition. This region has not yet fully recovered from the effects of the civil war. The average size of farms is between 160 and 300 acres. Some tracts of 500 to 2,000 acres are found, more often in the delta than in the upland. Cotton is the great staple and the money crop of the area. Some corn, oats, and hay are grown, but usually not enough to supply the local demand. Small fruits, some orchard fruits, and truck crops are grown for local use. The production of these crops might be extended with profit. In the upland section the fattening of cattle is already assuming some importance, and an extension of this industry may be looked for. The adaptation of soils to crops has

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not been worked out to any great extent in the area. Transportation facilities, both by water and rail, are fairly good. The wagon roads are very bad during wet weather. There are practically no local markets in the area.

BRAZORIA AREA, TEXAS.

The Brazoria area lies entirely within Brazoria County and covers 845 square miles, or 540,800 acres, comprising about three-fifths of the total area of the county. The Brazos River flows through the southwestern part of the area. Brazoria County, bordering on the Gulf of Mexico and extending inland a distance of about 35 miles, lies entirely within the Coastal Plain. The area surveyed is separated into two physiographic divisions—the treeless prairie and the Brazos alluvium. The open-prairie region has a rise in elevation inland from the Gulf of about 1 foot to the mile. The alluvium which is found along the Brazos River extends back from the river for a distance of from 2 to 8 miles. Narrow ridges, ranging in elevation from 2 to 6 feet, have been deposited in these bottoms by the various sloughs and creeks.

Of the eight soil types found within the area surveyed the Houston black clay is the most extensive, covering 272,576 acres, or 50.7 per cent of the area surveyed. This is one of the prairie soils, and comprises about three-fourths of the area of the treeless prairie. Small alkali spots and sand mounds occasionally occur in this type. The greater part of it is used as a range for cattle, but where it can be well drained it is considered a good soil for general farming. Rice has been found to give a good yield, and this soil will doubtless develop into one of the best rice soils of the country.

The Sharkey clay covers 133,056 acres, or 24.8 per cent of the area. This type occupies about three-fourths of the entire Brazos bottoms, forms the lowest areas, and is very hard to drain. It is covered with timber and a dense undergrowth of vines and bushes. Where it can be well drained it is a strong soil for sugar cane, corn, and cotton. This soil is subject to frequent overflows, and the silt deposited by the water, added to the vegetable matter contributed by the trees and undergrowth, makes it very rich in organic matter.

The Lake Charles fine sandy loam covers 38,784 acres, or 7.2 per cent of the area. It is usually found in the form of low, broken ridges back from the streams. Alkali spots and sand mounds sometimes occur in this type. The greater part of the soil is used for a cattle range, but some of it is used for farming purposes. It is very easily cultivated and, on account of its moisture-holding properties, is quite desirable for the production of the truck crops and pears. In some cases it is necessary to drain areas of this soil before cultivation, but it is usually supplied with good natural drainage.

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The Yazoo sandy loam covers 31,872 acres, or 5.9 per cent of the area. It occurs in the form of narrow ridges along the river and smaller streams. It is largely under a forest growth of pecan and oak. This is considered one of the best soils of the area for general farming purposes. It is easily cultivated and is admirably adapted to sugar cane, corn, and cotton. It is very fertile, and has at the same time the light, friable texture needed to secure the best results in the production of early truck for the Northern markets. The trucking industry is not as yet very largely developed.

The Galveston clay covers 31,168 acres, or 5.8 per cent of the area. This type is found near the Gulf, being separated from it by a narrow ridge of sand that borders the shore. It runs parallel to the Gulf and is from 3 tó 6 miles in width. This soil is wet and marshy even in the driest seasons. The only growth on it is salt grass. It is used only for a cattle range, and is not very good even for that.

The Calcasieu fine sandy loam covers 23,040 acres, or 4.3 per cent of the area. It usually occurs along the streams in broad areas extending back into the prairie a distance of from one-fourth mile to 2 miles. The areas are generally raised from 3 to 6 feet above the adjacent prairie and are thus well drained. Sand mounds of from 10 square feet to one-fourth acre in extent rise from 10 or 12 inches to 3 or more feet above the surrounding surface. The Calcasieu fine sandy loam is the principal truck soil of the area.

The Yazoo clay covers 9,152 acres, or 1.7 per cent of the area. It occurs as a ridge on both sides of Oyster Creek, following the stream almost its entire length. This is one of the most desirable soils of the bottoms, as it is very fertile, has good drainage, and is easily cultivated. The most of it is under cultivation at present. Cane is the principal crop grown, but the soil is also well adapted to cotton and corn. Oats do especially well on this soil, yielding from 40 to 65 bushels per acre.

The Galveston sand covers 1,152 acres, or 0.2 per cent of the area. It occurs as a ridge about one-fourth of a mile in width along the Gulf of Mexico. At present there is no part of this soil under cultivation, but with the aid of fertilizers it has been made to produce very good truck crops and fine watermelons.

This region was visited by a disastrous flood in 1899 and by a very destructive storm in 1900, both of which caused the loss of crops and live stock and the destruction of a vast amount of other property. The boll weevil made its appearance in the county about four years ago and has decreased the yield of cotton very rapidly. Sugar cane is, to a certain extent, taking the place of cotton, and the sugar mills are being rebuilt, while the cotton gins destroyed by the flood and storm have been allowed to remain in ruins. The farms vary in size from 100 to 5,000 acres. Perhaps one-third of the area included in farms

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may be under cultivation, although on some of the small plantations the proportion is greater. There are very few plantations of over 1,000 acres. The greater part of the planters own their own farms. Many of the negroes also own farms of from 10 to 100 acres and are in a very prosperous condition. The large plantations are gradually being subdivided. The greater part of the cultivated lands lie in the alluvial bottoms. The rice industry promises to give great impetus to the development of the prairie lands. Rice growing was introduced about four years ago and has not proved altogether successful, owing largely to inadequate water supply. With the construction of the several large canals now being surveyed this industry will attain great proportions.

Trucking and berry growing form an important part of the agriculture of the area. Strawberries form the principal crop, but blackberries and vegetables are also grown. These are all grown for the northern markets and have yielded profitable returns to the growers.

The pear industry was at one time very prosperous and important, but the pear blight has destroyed the greater part of the orchards.

VERNON AREA, TEXAS.

The area surveyed, comprising about 277 square miles, lies wholly within Wilbarger County, which is on the northern boundary of Texas, and is separated from Oklahoma by the Red River. In physiography the country is what is generally termed a high, rolling prairie. The county is drained by Pease River and Beaver Creek, both of which empty into the Red River. Only a small area is drained directly by the Red River. The prairie billows are for the most part long and gently undulating, with intervening loam plains or plateaus having a nearly level surface. The level of these loam plains is often broken by eroded depressions or "breaks," consisting of more or less circular areas having flat floors composed of the basal red clay, from which the overlying loam has been removed. A prominent physiographic feature of the area surveyed is a high sand ridge extending across the northern part, which rises to an elevation of about 100 feet above the level of the surrounding prairie. There is no forest to speak of in the area.

The Vernon loam, the first soil in order of extent, covers 62,528 acres, or 35.3 per cent of the area surveyed. The greater part of the area of this soil lies to the southeast and east of Vernon. It occupies the more level and slightly rolling portions of the prairie upland. The contour is always smooth and even and presents no abrupt outlines. For the most part this soil needs no artificial drainage, though occasional flat or slightly depressed spots are found where drainage would prove of great benefit. Corn, wheat, oats, kafir corn, and sorghum

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are the principal crops grown on this soil. It is essentially a wheat soil and is so recognized. The yield ranges from 25 to 40 bushels per acre, the former being about the average. Comparatively little cotton is grown upon this type of soil.

The Vernon sand covers 56,448 acres, or 31.8 per cent of the area. There are two phases of this soil—the upland and the lowland. The most extensive development of the upland phase is found in the northern part of the area, where it occurs as a high ridge 8 miles long by 5 miles wide. The lowland phase is found bordering both Pease and Red rivers throughout nearly their whole length. The upland phase occurs as a high, rather abrupt ridge or table-land, and the contour is, especially at the northern part of the area, generally hummocky and dunelike. The river-flat phase occupies a position usually from 3 to 6 feet above the rivers, and is level, save for the low dunes, from 2 to 10 feet in height, which have been piled up by the winds. The upland areas of this soil are always well drained. That part of the type which occurs at the river level is sometimes, though not often, flooded, and the water table is rather too near the surface for most crops. Upon the upland phase nearly all the ordinary farm crops are grown; the principal ones being kafir corn, sorghum, and cotton. Under the most favorable conditions, cotton produces as high as 1½ bales to the acre, but one-half bale is nearer the average. Very little wheat is grown. Apples, peaches, and melons do well on this soil. The greater proportion of the type is used for pasture land, and the lowland phase is used for little else.

The Vernon sandy loam covers 30,592 acres, or 17.3 per cent of the area. It reaches its highest development along the south side of the Pease River, where it forms a continuous strip entirely across the area. A few areas of the soil occur in isolated patches in depressions on the sand hills to the south of the river. The soil is generally well drained. Wheat does not yield as much on this soil as on the heavier Vernon loam, but the crop is surer. Corn, kafir corn, and cotton yield well, and with sufficient rainfall the latter will reach a bale to the acre in some cases. Oats are very successfully grown upon this type, yields of 65 to 80 bushels having been secured, though 40 bushels is about an average crop. This is a good soil for potatoes and other vegetables and for melons.

The Vernon clay covers 19,456 acres, or 11 per cent of the area. The largest and most continuous body of this type is in the southeastern part of the area. North of Pease River and to the south of Tolbert a quite extensive area of it also occurs. It occupies as broken and eroded depressions in the prairie, with intervening long, sloping hillsides. The floors of these eroded areas are nearly level, and are so hard and smooth that the surface water runs off freely. The soil is very little used for anything except pasture, and because of the com-

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paratively scanty vegetation a larger acreage per head of stock is required for range purposes than in the case of the Vernon loam.

The Vernon fine sandy loam occupies 5,248 acres, or 3 per cent of the area surveyed. It is found bordering the Red and Pease rivers near their confluence and extends inland from them for a distance of about half a mile. It occupies the bluffs along the river and is rarely found below an elevation of 40 or 50 feet above their beds. The soil is believed to have been deposited by the wind. Not much of it is under cultivation, it being used principally for pasturage. This is one of the best soils of the area for wheat, corn, oats, cotton, and other farm crops. Fruit and vegetables would also do well upon it.

The Vernon silt loam covers 2,880 acres, or 1.6 per cent of the area. It is found on the river flats of the Pease and Red rivers, usually near the bluff line, and occupies depressions in the river-flat phase of the Vernon sand. The drainage is poor, and artificial drainage would be difficult, if attempted, on account of the low situation of the soil. This type is used only for pasturage and has little agricultural value.

Rotation of crops is not practiced to any great extent in the Vernon area. Farming is done upon a large scale, the most improved labor-saving machinery being used. The greatest need of the country is irrigation, but water for this purpose, except on a very small scale, does not seem to be available. The absence at times of sufficient and seasonable rains, and the occasional disastrous hot winds of the late summer, make the success of crops uncertain. In favorable years wheat and oats give large yields, and even in excessively dry seasons from 4 to 6 bushels of wheat are harvested from each acre, so that there is almost never a complete crop failure. While cattle raising is still carried on to a considerable extent, the price of land is becoming too high to make this a profitable industry under range conditions. Within the past three or four years cotton has begun to be cultivated in the county and is fast becoming one of the most important crops. Watermelons and cantaloupes are grown very successfully in the area, and have a good reputation in the markets of the East.

TOLEDO AREA, OHIO.

The Toledo area covers about 403 square miles, and includes parts of Lucas, Wood, and Ottawa counties, Ohio, and of Monroe County, Mich. The city of Toledo lies within its boundaries. The area has a considerable frontage on Lake Erie, and is traversed by the Maumee River, which is navigable for large vessels at Toledo, making that city an important shipping point for lake traffic.

Geologically the area consists of glacial deposits, with a thickness ranging from 10 to 180 feet, resting on a limestone base, which rock outcrops in narrow ridges and knobs in the northwestern and southern parts. The surface in general is that of a rather level plain lying

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from 580 to 700 feet above sea level, and becoming more rolling near the streams. The deposits consist of clays, sometimes containing bowlders, and sands.

The area has been successively important in the production of live stock, grain, and wool, while to-day it is preeminently a dairy section, with general farming, stock raising and fattening, fruit growing, and the growing of special truck crops—all important interests. The agricultural practices are advanced in character. Many miles of public drainage ditches have been constructed, and wide areas of the best soils, formerly too wet for cultivation, have been reclaimed by use of tile drains.

The agricultural industry in the Toledo area is in a prosperous condition. Mortgages on farm property are being reduced and permanent improvements added to the farms. The farms are small, ranging from 20 to 150 acres, and are in most cases tilled by the owners. The price of agricultural land ranges from $30 an acre in more remote situations to $200 an acre nearer the cities and towns. Labor is fairly plentiful and efficient. Wages range from $16 to $18 a month, with board. Day labor during harvest costs from $1.25 to $1.75. The dairying is carried on mainly under the cooperative creamery system, and has reached large proportions. The soils are well adapted to this industry, and the farms have improved since it became a part of the average farm operations. The financial position of the farmers is said to be 20 per cent stronger than before the introduction of this interest.

Five types of soil are found in the Toledo area, the most extensive being the Miami black clay loam, covering 165,056 acres, or 63.95 per cent of the total. The soil has an almost level, sometimes depressed, surface and is rich in organic matter, having been formed under more or less swampy conditions. Nearly the whole of the area east of the Maumee River and about 50 per cent of the area west of the river is occupied by this type. It is this soil that has been so extensively underdrained and in this way converted from land of extremely limited agricultural use to the most productive soil of the area. This is the typical corn and grass soil of the area. It is also used extensively in the production of wheat, although where the soil is most fertile the crop is apt to lodge. Dairying and stock raising are also important interests, as is also trucking. Onions seem the best truck crop for this soil. Wheat yields from 15 to 25 bushels per acre, oats from 30 to 60 bushels, and corn from 40 to 140 bushels. Potatoes yield from 100 to 500 bushels per acre, but the quality of the tubers is not as good as on the other soils. Berries, apples, and peaches seem to thrive on the Miami black clay loam.

The Miami sand, next in extent, covers 36,672 acres, or 14.21 per cent of the area surveyed. This is a deep, sandy soil of loose texture

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found mainly in the western part of the area, extending in a broad body 4 or 5 miles wide parallel to the Maumee River, from which it is about 3 miles distant. Its elevation is somewhat above that of the other types. The surface consists of a series of knolls and ridges, with broad, flat expanses of lower land between them, where swampy conditions sometimes prevail. There are large areas of native forest still standing on some of the wetter lands. Such lands, when cleared, become the most productive areas of this soil type. This soil is derived from beach sands laid down during the iceberg stage of the glacial period. Grass, corn, truck, and fruit are grown. The quality of these products is good, but the yields are usually from 15 to 30 per cent lower than on the heavier soils of the area. The Miami sand is best adapted to certain of the truck crops and fruit.

The Miami sandy loam covers 30,528 acres, or 11.83 per cent of the area surveyed. This soil varies in texture and depth from a fine sandy loam 8 inches deep to a somewhat more sandy soil from 20 to 30 inches deep, the variation seemingly being due to the influence of contiguous soils. The surface is rolling and the elevation slightly higher than the Miami black clay loam and Miami clay loam. Drainage is resorted to only in the depressions. The soil is easily tilled and used chiefly for grain, grass, corn, and truck. It is best adapted as a whole to corn and truck. The average yield per acre of wheat is 18 bushels, of oats 35 bushels, of corn 50 bushels. Fruit does well. The quality of all products of this soil is good.

The Miami clay loam covers 20,352 acres, or 7.88 per cent of the area. The soil occurs as knolls and ridges in areas of the Miami black clay loam and in well-drained situations along the streams. While usually more friable than the latter soil, it is somewhat difficult to till. The surface is generally flat, but enough rolling to provide surface drainage. Notwithstanding this, underdrainage is practiced to some extent with marked beneficial results. With proper management this type can be maintained in a high state of fertility. It is an excellent soil for corn, wheat, oats, and grass, and, as in addition it makes good pasture land, is admirably adapted to dairying. It is typically a wheat soil.

The Miami loam, covering 5,504 acres, or 2.13 per cent of the area, is a fertile black soil occupying terraces and bottom lands along the streams, the most important areas bordering the Miami River. The surface of this soil is in general flat, but with sufficient undulation to provide good natural drainage. Corn and other grains and truck thrive. On the higher terraces fruit does well. Corn yields from 40 to 100 bushels, averaging about 75 bushels, per acre, and wheat from 20 to 35 bushels.

As far as adaptation of soils to crops is concerned there is not as much to be said as in more sparsely settled and less advanced commu-

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nities. There is, however, an opportunity for greater specialization, already being seized by some, in the production of fruit and truck crops. Onions, cabbages, and potatoes find suitable soils, and celery might be added to these. The fruits chiefly grown are peaches, grapes, raspberries, and apples. The most extensive orchards and vineyards are found near the Maumee River and along the lake.

COLUMBUS AREA, OHIO.

The Columbus area has an extent of about 471 square miles. It lies in central Ohio, around the city of Columbus, and includes parts of Franklin, Pickaway, Madison, Fairfield, and Licking counties. The area geologically consists of a deposit of glacial drift with an average thickness of 200 feet. The rocks underlying this deposit are in the west limestones, passing as one goes east into shale and then into sandstone. The materials of the drift are sand, gravel, and a superimposed bowlder clay, the latter having the greatest influence on the soils. The physiography of the area is that of a plain more or less modified by the erosion usual in the building of a drainage system. The principal streams are Scioto and Olentangy rivers, Big and Little Darby and Big and Little Walnut creeks. These streams flow south into the Ohio River, their branches extending east and west, through comparatively narrow valleys, the largest, that of the Scioto, being from one-fourth mile to 1½ miles wide.

The farmers of the Columbus area are now in a prosperous condition, it is said much better than existed one or two decades ago. The farms are well improved and present a thrifty appearance. They range in size from 20 to 500 acres, with the average size about 85 acres, and are tilled largely by the owner and his family. Where rented on shares, two-fifths of the crop goes to the landlord, while the money rent ranges from $4.50 to $6.50 an acre. The price of farm lands ranges from $40 to $120 per acre. The condition with respect to labor might be more satisfactory, especially at harvest time. Outside the zone of city influence, within which market gardening is of major importance, the principal products of the area are grain, beef, mutton, pork, butter, and cheese. Wheat is the chief direct money crop and is sold largely to local elevators. Corn and hay are used to feed and fatten live stock and to support the small herds of a half dozen or so milch cows found on the average farm. The cooperative dairy system, so extensively developed in the Toledo area, does not maintain here, and but four creameries and few large dairy herds are seen, the great bulk of the dairy products being homemade. More attention has recently been given to the production of fruit, and new orchards are being set out. There is good profit to be made in rational orcharding on the soils of this area.

The Miami clay loam, covering 222,336 acres, or 73.6 per cent of

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the area, is not regarded as a naturally fertile soil, because of deficiency in organic matter, but it is capable of great improvement and when once brought to a high state of fertility can be easily maintained in that condition. The areas along the streams are better drained and more fertile, but drainage is deficient in the type as a whole, and artificial drainage has to be resorted to on all the more level areas to insure good crops. Under the efficient methods of the farmers of this area, this soil seems well adapted to the general farm crops. The yield per acre of wheat ranges from 20 to 35 bushels, of oats from 40 to 60 bushels, and of corn from 40 to over 100 bushels. A system of rotation is practiced providing for two or more years of grass (clover and timothy) and pasture. Fruit does well on this soil, and almost every farm has its orchard.

The Miami black clay loam, covering 33,792 acres, or 11.2 per cent of the total area, is one of the strongest, if not the strongest, soil in the area. It occurs in two principal bodies, while smaller tracts, ranging from 5 to several hundred acres, are scattered throughout the area. The areas of this soil are nearly always level or basinlike, lying from 1 to 3 feet below the surrounding soils. Many of the areas were formerly under water for a part of the year, but nearly all have now been underdrained and brought under cultivation. The soil is very fertile, and owing to the manner of its formation contains large proportions of organic matter. The soil is especially adapted to corn, and so far as fertility and texture is concerned it should be suitable for all the general farm crops. In practice, however, the winter grains and grasses do not do very well, being apt to winterkill from the effects of heaving. The soil is also naturally moist and in very wet seasons small grain grows too rank and lodges. Corn yields from 40 to 120 bushels and wheat, in favorable seasons, from 20 to 40 bushels per acre.

The Miami loam, covering 26,880 acres, or 8.9 per cent of the area, occurs in the lower terraces along all the larger and many of the smaller streams. The surface is generally flat, though occasionally gently rolling. The elevation above the streams is usually slight, and many of the areas are subject to annual overflow, except where protected by levees. Artificial drainage is extensively practiced. This soil is a deep, fertile black loam, and is in great demand for the production of corn and late vegetables. Danger from spring floods and a tendency to heave make it less desirable for the winter grains and grasses.

The Miami gravelly loam, covering 18,944 acres, or 6.3 per cent of the area, is locally known as "gravelly second bottom land." It occurs as terraces along all the streams. The surface is flat or gently rolling, and the drainage is good. The gravel content varies from 10 to 30 per cent, the fragments being chiefly of limestone. Bowlders also occur in the gravelly subsoil. The main differences between this soil and the

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Miami loam are the presence of gravel and the smaller proportion of organic matter in the former type. This soil is used to a great extent for market gardening near the cities and towns. It is also well adapted to the general farm crops and tobacco. Corn yields from 40 to 60 bushels and wheat from 15 to 30 bushels per acre.

Fully one-fifth of the whole area has been reclaimed or improved by tile drains. Most of this land is of the Miami black clay loam type—one of the most fertile soils of the area. The reclamation of swampy areas is about completed, but artificial drainage is still being extended. This improvement has added greatly to the production of the area.

The origin and characteristics of the soils of the Columbus area are quite clearly marked and the adaptation of soils to crops seems more pronounced than in areas where the soils are less distinct. It is perhaps for these reasons that the farmers have gone so far in a rational adjustment of the crops to be grown to the soils at their disposal. Moreover, by means of underdrainage and pump and tank irrigation—the latter confined to the market gardens—the natural limitations of several of the soil types have been modified and their adaptation materially widened.

UNION COUNTY AREA, KENTUCKY.

The area of Union County, Ky., is approximately 361 square miles. The county lies in the western part of the State, a part of its boundary being formed by the Ohio River. The Tradewater River separates it from Crittenden County on the southwest, while Webster and Henderson counties are contiguous on the southeast and northeast, respectively. Morganfield (population 2,000) is the largest town and the county seat. Sturgis and Uniontown are towns of next importance. The underlying rocks have little or no influence on the soils of the county, which are for the most part deposited either by water or wind action. Very possibly both agencies have entered in the distribution of this material. Union County comprises two main physiographic features—upland, embracing the larger area, and the Ohio River bottom. The bottoms lie at an average elevation of 20 feet above mean water level and are separated from the upland by a bluff from 50 to 100 feet high. In the southern part of the county this bluff is a precipitous sandstone cliff, but farther north the ascent is more gradual. The surface of the upland varies from gently undulating to rolling and hilly.

Union County is distinctly an agricultural community, and the condition of the farmers is above the average for the country at large. The farms, containing from 75 to 300 acres, are usually operated by the owners. The agriculture is diversified. Wheat, corn, tobacco, and hay are all extensively and profitably grown. Rotation of crops

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is practiced, and the fertility of the soils, naturally high, is kept up by other proper cultural methods. Considerable live stock, including many work animals, is kept. The raising of cattle and hogs is a large and growing industry.

The Miami silt loam is the most extensive and important soil in the area, covering 154,176 acres, or 66.7 per cent of the total. It occupies the upland and has all the varied topographical features of this part of the country. The soil is derived from loess, a mantle of which from 3 to 20 feet in thickness entirely covers the upland. The soil is well drained and yet retains moisture well. Only in the steep areas does it wash badly. Such areas should be put into permanent bluegrass pastures. The principal crops are wheat, corn, grass, and tobacco. The average yield per acre of corn is 35 bushels, of wheat, of superior quality, from 18 to 20 bushels. An excellent grade of heavy export tobacco is produced, the yield averaging about 1,200 pounds. Clover has been the main hay crop, but of late it has become difficult to secure a good stand on some fields. It is thought the substitution of some other crop for a few years will remedy this condition. Stock peas are also grown as a forage crop. Fruit does well, but is not grown commercially. It is suggested that the peach industry could be profitably introduced on the shaly slopes in the southern part of the area. There would seem to be no reason why alfalfa should not succeed on this soil and form a valuable adjunct to the stock-raising interests.

The Waverly silt loam, locally called "black bottom land," is found in many parts of the upland, covering in all 25,216 acres, or 10.9 per cent, of the area surveyed. The principal areas are found in the level country along Pond Fork and in the eastern section along Highland and Caseys creeks. The physiography and physical character suggest its origin—a combination of shoal-water deposition and marsh accumulation. In texture the soil is eminently adapted to agriculture, becoming mellow and loamy when stirred in the proper condition. Naturally the drainage is insufficient and much of the cultivated area has been underdrained, although where the areas are narrow a mere deepening of the stream channel and running of a few ditches is all that is necessary. All the crops grown in the area do well on this soil type. The yield per acre of corn averages 60 bushels; of wheat, in favorable seasons, from 25 to 30 bushels. The quality of wheat, however, is not so good as on the upland. The straw is apt to grow too rank and to lodge. Tobacco yields well, 1,300 pounds per acre being a fair estimate.

The Yazoo clay, covering 24,448 acres, or 10.6 per cent of the total area, is the principal river-bottom soil. About half of this area is under cultivation, the remainder being heavily timbered and often marshy. The soil is a recent alluvial deposit and is yet subject to

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overflows which add more material and fertility. The Yazoo clay is a strong, fertile soil and capable of producing good yields of various crops. On account of danger of damage from overflow, however, it is used almost exclusively for corn. On the higher areas winter grains and tobacco are successfully produced. Corn can be planted a month later on the Yazoo clay than on the upland soil. Corn averages 45 bushels per acre year by year.

The Memphis silt loam, covering 17,984 acres, or 7.8 per cent of the area surveyed, occurs in long, narrow strips along the streams throughout the upland. The soil is a wash from the Miami silt loam and is usually underlain by material similar to that of the Waverly silt loam. It is apt to be "crawfishy," and most of the cultivated areas have been underdrained. Corn, wheat, and hay are the crops grown, to the first of which the soil is best adapted, the yield averaging perhaps 40 bushels. Some tobacco is grown, but it suffers some from "frenching," and the soil is less desirable for this crop than the upland soil.

The Sharkey clay, covering 4,032 acres, or 1.7 per cent of the area surveyed, is a heavy, impervious clay soil, subject to overflow, in need of drainage, and difficult to till. But little of it is under cultivation. With proper drainage and cultivation the texture is greatly improved, the surface soil becoming quite mellow and loamy, greatly resembling the Waverly silt loam. Indeed, much of the latter soil is said to have formerly had a character almost identical with the untilled areas of Sharkey clay. A heavy forest growth covers most of the areas of this soil type.

The Miami fine sandy loam, covering 3,072 acres, or 1.3 per cent of the area surveyed, occupies low ridges immediately along the Ohio River. Nearly all this soil is under cultivation, corn being the chief crop grown. Sandier areas are used for melons, and it would seem that truck growing could be profitably introduced.

The Sturgis fine sandy loam covers 2,176 acres, or 0.9 per cent of the area surveyed. Its limited extent makes it relatively unimportant. The staple crops of the county are produced on this soil, but the yields are less than on the silt soils, and, especially on the ridges, the crops are apt to suffer from drought. Alfalfa would seem better adapted to this soil than the other clovers, and melons ought to prove a profitable crop.

The adaptation of soils to crops in Union County, while following broad general lines, has not received the attention given to the subject where there are a greater number of special crops produced. No one crop has predominance over any very extended area. There would seem to be opportunity for the development of the fruit industry on the sandy soils in the Ohio River bottoms and the bottoms along some of the streams of the upland.

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POSEY COUNTY AREA, INDIANA.

Posey County is situated in the extreme southwestern corner of the State, and is bounded on the south by the Ohio River and on the west by the Wabash River. It has an area of 387 square miles. The survey covered the entire county. Mount Vernon is the largest town in the area, with a population of 6,000 or 7,000. New Harmony and Poseyville are towns next in importance. Rail and water transportation facilities are both good.

Posey County is divided into two main physiographic divisions—the bottoms of the Wabash and Ohio rivers and the upland, the latter separated from the bottoms by a distinct bluff or escarpment. The surface of the bottoms is flat or gently rolling, with occasional low, usually sandy, ridges. There are generally two or three well-defined terraces between the rivers and the bluffs. The surface of the upland is undulating. Low, rolling hills descend to the broad stream valleys in moderate, symmetrical curves. The general slope is toward the southwest. Big Creek, emptying into the Wabash, drains a large proportion of the upland. Black River drains a part of the northern section, and a few minor streams in the south flow directly into the Ohio River. The rocks underlying the county belong to the Coal Measures and are usually shales or shaly sandstones. The average depth to the rocks is about 20 feet, which represents the thickness of the superimposed loess deposit from which the upland soils have been directly derived and which influences to a great degree the soils found in the bottoms. In the eastern part of the county occur a few outcrops of an impure limestone.

Posey County is a prosperous agricultural community. The dwellings are well constructed, the live stock is given warm shelter, and implements are housed when not in use. The average size of the farms is about 65 acres. Much of the land is held at $100 or more per acre. Farms are generally worked by the owners. White labor is employed on the larger farms, but generally all the work is done by the farmer and his family. The staple crops of the county are corn, wheat, hay, and melons. The upland, which is best adapted to wheat, yields an average of 20 bushels per acre, and of corn about 35 bushels, while from 1½ to 3 tons of clover and timothy hay are cut to the acre. The greater proportion of the corn is grown on the bottoms, where the yield is about 65 bushels per acre. The sandy hills and ridges are used for melon culture, for which the county is famous. Between 300 and 400 carloads are shipped annually from Poseyville, the chief shipping point. The melons, which are of superior quality, find a ready market in Cleveland, Indianapolis, and Chicago, and even as far east as Pittsburg and Buffalo.

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The Miami silt loam, covering 149,376 acres, or 60.3 per cent of the area, is a typical silt loam containing very little sand and clay. Owing to its loessial origin, it is remarkably uniform throughout the wide area occupied. The texture is slightly plastic when wet, but loamy when dry. The soil is found in all parts of the upland and has all the topographic features of that part of the county, although in general the surface is moderately rolling. The soil is fertile and has a wide crop adaptation. The staple crops are wheat, corn, clover, and timothy. Fruit and vegetables are grown for home use. The average yield per acre of wheat is 20 bushels, of corn 35 bushels, but in favorable years 25 or 30 bushels of wheat and as high as 50 bushels of corn are produced. The apple seems the fruit best adapted to this soil.

The Yazoo clay, covering 30,720 acres, or 12.4 per cent of the area, is the most extensive of the bottom soils. Much of this type is subject to annual overflow and used only for corn, which yields an average of 45 bushels per acre. Some of this type, however, is found on the second terrace, out of reach of any except the highest floods, and such areas are used for wheat (yielding 25 to 30 bushels per acre) and grass (1½ to 2 tons per acre). The natural forest growth of this soil includes the pecan, and many bushels of this nut are gathered annually. Several carefully kept pecan orchards were seen. These are said to be quite profitable.

The Waverly silt loam, covering 16,384 acres, or 6.6 per cent of the total area of the county, is the third soil in agricultural importance. It is a mellow black loam, sticky when wet, but easily tilled when in proper condition. The principal areas occur in the vicinity of Poseyville in the northern and around Mount Vernon in the southern part of the county. The surface is generally level or gently sloping. The soil originated in washings from the loess carried into natural depressions, where they were intermingled with organic matter. Drainage has subsequently been established either naturally or artificially. The average yield of corn on this type is 50 bushels per acre. Clover yields 1½ to 2 tons of hay per acre, with the second growth for seed.

The Guthrie clay, covering 14,592 acres, or 5.9 per cent of the area, occurs in one tract in the southwestern corner of the county. This is locally known as the "flat woods" land, a name taken from its level surface. It is thought this area represents an old flood plain of the Ohio and Wabash rivers. The soil is probably the least valuable of the Posey County types, and this is chiefly due to its poor drainage. Where the soil has been under cultivation for some time it produces a fair yield of corn in dry seasons. Wheat in favorable seasons yields 15 bushels to the acre and clover and timothy do well. Some areas of the type have been underdrained with good results. The great need, however, is for a main drainage canal into which to turn the lateral ditches.

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The Memphis silt loam, covering 9,408 acres, or 3.8 per cent of the total area, occupies the narrower valleys in the uplands forming the flood plains of the streams. It is subject to frequent overflow, and is generally wet and needs drainage before it can be cultivated. In the narrower areas a mere deepening of the stream channels is often sufficient, but lateral tile drains should be used in most cases. This soil, being derived by stream sedimentation from the fertile upland soils, is a strong and productive type. Corn is the chief crop and the one to which the soil is best adapted. The average yield per acre is 50 bushels. The soil resists drought well, and this, in a country where late droughts are apt to reduce the crop yields, greatly enhances its value.

The Yazoo loam, covering 8,320 acres, or 3.4 per cent of the area, is found in the Wabash River bottom. It is a fertile, easily tilled soil, and though of limited extent is of considerable agricultural importance. It is the principal wheat soil of the Wabash bottom, producing on the average 25 bushels per acre. The average yield of corn is good. Clover and timothy about complete the list of crops grown on this soil type.

The Miami sand, covering 7,680 acres, or 3.1 per cent of the area, is a very important soil in Posey County, being the chief soil used in the production of watermelons. The type occurs almost exclusively in the northern and western part of the county, usually lying in strips from a quarter of a mile to a mile wide at the foot of the bluffs facing the Wabash and Black rivers. The texture is open and porous and the soil is too droughty for the general farm crops. Before the introduction of melon growing it was considered a very inferior soil and brought very low prices, but the recognition of its adaptation to the production of melons has greatly enhanced its value.

The Miami sandy loam, covering 3,584 acres, or 1.4 per cent of the area, on account of its limited extent is of comparatively little agricultural importance. Most of it lies in the bottoms of the Black and Wabash rivers. The surface is level but well drained. In origin the soil is alluvial, and it contains considerable organic matter. In adaptation to crops the soil shows great diversity, and it is hard to assign the reasons for the variation. In some localities it gives large yields of corn and wheat; in others the yields fall below the average of the county. In a few places melons are grown on this soil, and it is thought that larger areas might well be devoted to this crop.

The Miami fine sandy loam, covering 3,456 acres, or 1.4 per cent of the area, is another river-bottom soil. It occurs as low, narrow ridges immediately bordering the Wabash and Ohio rivers and in other situations throughout the bottoms, and along the lower courses of Black River there is one area of considerable extent. The soil is of alluvial origin. It is nearly all under cultivation, although there are a few

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areas of nearly pure sand upon which no crop will grow. Corn is the chief crop, and where there is a considerable proportion of clay in the soil an average yield of 40 or 45 bushels is secured. Watermelons are grown on areas too sandy for the other crops. Fair yields of wheat are secured on areas lying above high-water mark, and garden vegetables, though not extensively grown, are successful crops.

The Yazoo sandy loam, covering 2,752 acres, or 1.1 per cent of the area, is an important soil type, but by reason of limited extent in Posey County it has but little influence on the local agriculture. It is found chiefly in the higher parts of the Wabash River bottoms, near New Harmony. It is situated at the foot of sandy bluffs. For corn and wheat this soil is less suitable than the Yazoo loam. The sandy areas are well adapted to melon culture, and they are beginning to be used for this purpose.

The Griffin clay, covering 1,600 acres, or 0.6 per cent of the area, is found in the valley of the Black River at the northern edge of the county. It probably extends some distance into the adjoining county. The soil is entirely distinct from the other soils of the area. It is composed of an admixture of medium to fine gravel, coarse sand, and clay, and is underlain by a stratum of gravel at a depth of from 4 to 5 feet, which gives it fair natural drainage which would hardly be indicated by the position of the area or the soil texture. The materials composing this soil type are believed to be of glacial origin. The greater part of this type is now under forest, but large areas are being cleared and brought under cultivation. Corn is the principal crop and yields of from 50 to 60 bushels per acre are secured. Wheat and oats are also grown, and one field of the former gave an average yield of 38 bushels per acre in the season of 1901–2. Such a yield is, however, considerably above the average. At first this soil is very difficult to till, but with a few years of cultivation, if good cultural methods are employed, it becomes more friable and loamy.

There is a general recognition of the adaptation of certain soils to particular crops. The introduction of melon culture has enabled a better adjustment of such relations, and it is believed that this industry can well be extended on the sandy soils of the area. Other truck crops might also be grown on these soils with greater profit than is secured from staples now grown. The growing of fruit on the uplands is also suggested as a possible addition to the interests of that part of the area.

TAZEWELL COUNTY AREA, ILLINOIS.

Tazewell County comprises an area of about 645 square miles, located on the eastern bank of the Illinois River, a little northwest of the center of the State. Pekin, the county seat, has about 8,000 inhabitants. Other important towns are Washington, population nearly

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2,000, and Delavan, population nearly 1,500. The county has a population of about 35,000. The principal industry is agriculture.

The high bluff forming the eastern boundary of the Illinois River divides the county into two physiographic regions—the flood plain of the river and the upland. The upland consists of a high, rolling plateau, interspersed with broad, level prairies. Geographically Tazewell County consists of a basal structure of sandstones and shales belonging to the Upper Carboniferous rocks, covered with glacial deposits. The soils of the terrace and bottom lands are alluvial, and comprise eight of the ten types mapped, while two types occupy almost the entire upland.

Probably every foot of surface of Tazewell County not occupied by a town site is used for some agricultural purpose, and perhaps 80 per cent of the area is tilled, the remainder, including the wooded stream bottoms and slopes, being used for pasture. The value of land varies considerably, but there are few farms on the Miami black clay loam or Delavan silt loam that can be purchased for less than $125 per acre. In general, the farm lands are paying a good rate of interest on their valuation and are locally considered good security for loans. Fifty per cent or more of the farms are operated by the owners, while those rented are usually held on long leases by tenants who sooner or later expect to become owners. Where worked on shares, the owner receives half the products of the farm. Quarter-section farms are common, while farms of less than 80 acres are rare. The farmer and his family do much of the work on the smaller farms. The land is level and free from gravel, and horse-power implements are very generally used. Gang plows, disk harrows, grain drills, etc., are operated by four-horse teams. The cultivating is done with two-horse teams and wheel cultivators, and steam-power thrashers are used.

Corn forms the basis of the agriculture of the area. Oats occupy second place, and clover and timothy hay stand third. Wheat and rye, though grown, are of subordinate importance. Fruit is produced mainly for home consumption, very little being shipped out of the county. Small quantities of watermelons, sweet potatoes, and celery are raised in the western part of the county. Pekin and Peoria furnish local markets. The distilleries, breweries, and glucose factories located at these towns furnish a local demand for grain. The bulk of the crop, however, goes to Chicago. Live stock goes to the same market. A considerable proportion of the butter, poultry, meats, and early vegetables used locally come from outside the county.

The Tazewell silt loam, covering 224,960 acres, or 54.5 per cent of the area surveyed, occupies the great part of the upland. The surface varies from a nearly level to gently undulating or rolling plain. The highest point in the area of this soil is about 350 feet above the Illinois River. The natural surface drainage is well established, but the tilled

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areas have been very generally tile-drained. The soil is derived from the weathering of the glacial material deposited as moraines or till. Corn, wheat, oats, and grass are the chief crops. The yield per acre of corn ranges from 40 to 60 bushels, of wheat from 20 to 25 bushels, of oats from 40 to 50 bushels, and of hay from 1 to 1½ tons. A good sod is easily established on this soil, which not only prevents washing, but would form the basis for a profitable dairy industry. Small orchards and vineyards are found on nearly every farm, but only one commercial orchard was seen. The climate and soil are well adapted to nearly all the fruits.

The Miami black clay loam, covering 61,184 acres, or 14.8 per cent of the area, is a fertile black soil found in the upland. It owes its existence to the presence of a series of occasional moraines, between which a level floor of glacial till has caught the drainage and wash of the higher lands. The finer particles thus accumulated have been intermingled with the remains of the rank vegetable growth of such swampy conditions. All the areas of this type have been drained and brought under cultivation. It is a typical corn soil, producing between 50 and 60 bushels to the acre on an average, while frequently the yield exceeds 90 bushels per acre. Oats, wheat, and clover are subordinate crops, giving yields somewhat above the average for the county. Many fields located on this soil have been cultivated fifty years without any systematic fertilization and without any appreciable decrease in the yields.

The Miami loam covers 32,512 acres, or 7.8 per cent of the area. It is a friable, easily worked soil, with a surface generally level and free from stones. Slight depressions are more loamy than the typical soil through the accumulation of silt and clay washed from the higher areas, and also from the incorporation of more organic matter, and for this reason are generally preferred.

The Miami loam is farmed in a regular rotation of corn, wheat, oats, and grass. The yield per acre of corn ranges from 35 to 50 bushels, of wheat from 18 to 25 bushels, of oats from 25 to 35 bushels, and of hay an average of about 1 ton. The soil is adapted to canning crops, and it is believed the farmers could get greater profits from these than from the general farm crops now grown. Some varieties of pears, notably the Kieffer, could also be successfully produced on this type.

The Lintonia loam, covering 29,056 acres, or 7 per cent of the area, is most extensively developed in the bottom lands along the Mackinaw River. Smaller areas occur in other parts of the bottoms of the rivers and streams. The surface is level, except where broken by sloughs. It is rarely flooded. It is naturally fairly well drained, but in addition large areas have been tile-drained. The water table stands near the surface and the moisture supply is abundant. Corn yields from 40 to 50 bushels per acre, wheat 25 bushels, oats 40 bushels, and hay

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from 1 to 1½ tons. This soil might well be employed to produce cabbage, onions, cucumbers, and other market-garden crops.

The Delavan silt loam, covering 25,600 acres, or 6.2 per cent of the area, comprises the higher-lying parts of the level plain lying west of the glaciated uplands. The surface of this type is uniformly level, forming a broad expanse of low prairie. The natural drainage is accomplished partly by the larger secondary streams and by the gravelly till stratum occurring below the loess subsoil. Underdrainage is seldom found necessary, but open ditches are used in some localities. The soil is derived from the loess and the subsoil in part from the same material and in part from reworked glacial till. It has been under cultivation from the time of earliest settlement and has constantly produced crops of grass and grain without apparent diminution of yield and without addition of fertilizer except on limited tracts through the feeding of live stock. The average yield per acre of corn ranges from 35 to 50 bushels, of wheat from 18 to 25 bushels, of oats from 35 to 40 bushels, and of hay from 1 to 1½ tons. During favorable seasons these yields are not uncommonly exceeded. No change in crops can be suggested for this soil, but the keeping of more stock and applying the manure to the fields should be practiced to guard against ultimate deterioration in their fertility.

The Miami fine sand, covering 22,976 acres, or 5.6 per cent of the area, lies chiefly in Spring Lake Township between the Illinois and Mackinaw bottoms. There is little difference between the soil and subsoil of this type, and its deep, open texture gives it excellent, if not excessive, drainage. So marked is the ability to absorb water that the areas are without minor stream drainage. In some places the sand is shifted by the winds into dunes. The whole area is thought to be gradually extending eastward in this way. The main crops grown are those common to the area. There has, however, been some attempt at specialization in grapes, peaches, pears, small fruits, watermelons, and sweet potatoes. In other areas this type has been found valuable for these and other truck crops, and there is opportunity for the introduction and extension of these industries in Tazewell County.

The Yazoo clay, covering 13,696 acres, or 3.3 per cent of the area surveyed, occurs along the Illinois River. Its surface is level, indented only by shallow sloughs and lake basins. The Yazoo clay is under from 3 to 10 feet of water from December to the latter part of May. The rest of the year it is above water, but saturated below 2 feet. Very little of the soil is under cultivation. It could be reclaimed by diking and would amply repay the cost, as it is extremely fertile.

There is a small tract of peat in the county, amounting to 1,645 acres, or 0.5 per cent of the area. Corn, wheat, and oats are grown on this soil. A little celery is produced, and the type could well be devoted to this crop and to onions.

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The Mackinaw gravel, covering 1,088 acres, or 0.2 per cent of the area, is found only on steep slopes where glacial or alluvial gravels reach the surface. The type is for the most part uncultivated and of slight value to general farming crops. It might be adapted to grapes and peaches.

The Yazoo sandy loam, a widely distributed and important soil type, is represented in Tazewell County by one area of only 128 acres, occurring in the Illinois River bottoms. It is planted to corn and produces about 40 bushels per acre.

Although ten types of soil are found in Tazewell County, the crop rotation practiced upon all is nearly identical. The only adaptation of soils to special crops is where the peat is used for celery and the Miami fine sand occasionally for watermelons and sweet potatoes. More could be accomplished in these lines.

CLINTON COUNTY AREA, ILLINOIS.

Clinton County comprises an area of about 314,111 acres, or 490 square miles. The county seat is Carlyle, a town of about 2,000 inhabitants, situated on the Kaskaskia River, 45 miles east of St. Louis. Three railroads cross the county. The total population is about 20,000. The chief industries are agriculture and coal mining.

The physiography of Clinton County consists of a level prairie, interrupted only by broad bottoms along the principal streams and by scattered hills formed by the morainal deposits of the Illinois glaciation. The general slope of the surface is toward the southeast, the grade being so slight as to be scarcely perceptible. None of the hills rise more than 250 feet above the plain. The Kaskaskia River and its tributaries have cut broad, shallow bottoms through the plain and to-day are building up flood plains. Only the smaller streams are deepening their channels. The basal rocks of Clinton County consist of sandstone, limestone, and shale of the Upper Coal Measures. These are overlain with glacial till of an average thickness of 20 feet, above which is a stratum of mottled gray and yellow silty clay from 2 to 6 feet thick. This material forms the subsoil of nearly all the soils of the prairie region. The surface soils of the prairie are derived from a mantle of very fine sand and silt varying in thickness from 8 to 24 inches. While the more extensive soils are of loessial origin and should therefore be fertile, the fertility has either been exhausted by continuous cultivation to a single crop or has not been put in available form through lack of proper drainage and aeration, or else the presence of hardpan has interfered with proper root growth or produced a droughty condition of soil inimical to the best crop yields. The other soils occurring in the alluvial bottoms are often subject to overflow, need diking, and besides are covered by heavy forests, which conditions seem to have discouraged the reclamation of areas easily the most

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productive in the county. The average size of farms is perhaps 100 acres, and the owner is generally the tiller. The greater part of the prairie soil is given to winter wheat, the crop grown since the time of first settlement. The yield is only from 8 to 15 bushels per acre. A beginning has been made in commercial fruit growing, and it is thought the salvation of the area under which the hardpan occurs is to be found in the extension of this industry. The apple is particularly well suited to this region. There has been little attention paid to the adaptation of special crops to the soils of the area. There will be greater opportunity for diversification of the crops when the bottom soils shall have been more generally brought under cultivation.

The Marion silt loam, covering 172,480 acres, or 54.9 per cent of the area, occupies the level prairies comprising the eastern three-fourths of the county, being interrupted only by the morainal hills, occupied by the Edgerton silt loam, and by the broad valleys of the streams. The material forming the soil is of loessial origin. The most important feature of the type is the presence of an iron hardpan between the soil and the subsoil. This hardpan stratum occurs at varying depths and is of different thicknesses and degrees of consolidation, but it is generally near enough the surface to adversely affect deep-rooted crops, excepting the tree fruits. This soil type is used chiefly for winter wheat, of which the average yield per acre ranges between 8 and 12 bushels. Oats produce about 25 bushels and clover and timothy hay three-fourths ton per acre. Only enough corn and potatoes are grown for home consumption. Apples thrive, and a few farmers have given special attention to this crop with success; but as a general thing the small orchards, which are to be found on almost every farm, are poorly cared for. The fruit interest should be systematically developed.

The Miami silt loam, covering 57,472 acres, or 18.3 per cent of the area, occupies the gently rolling prairie in the western and northwestern part of the county. The surface configuration gives better drainage than is found farther east. The soil is derived from loesslike materials, and differs from the other prairie types in being deeper, richer in organic matter, and not having the hardpan. As a consequence it is more fertile and retains moisture better than the other soils. Wheat and corn both do well. The former yields from 18 to 20 bushels per acre, the latter from 40 to 45 bushels. From 1 ton to 1½ tons of hay per acre are secured. Small orchards are numerous, but the product is for home consumption only. More dairying is practiced on this soil than on the others, the milk being shipped to St. Louis.

Waverly silt loam, covering 42,112 acres, or 13.4 per cent of the area surveyed, occupies the greater proportion of the bottoms of the smaller streams and the higher parts of the bottoms of Kaskaskia

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River. Near the bluffs the surface is slightly inclined toward the streams, but elsewhere it is level. The soil is subject to overflow during the spring freshets and infrequently at other times. The water table is near enough the surface to give needed moisture throughout the growing season, during which time the areas are usually well drained. A little diking would entirely protect the areas of this type from floods and greatly add to its crop adaptation and agricultural value. The soil has been derived from the wash from the higher land and from sediments laid down by the streams. At present three-fourths of the area is under forest, in which there are occasional pecan trees. The remainder of the area is cultivated in corn, which yields an average of 40 bushels per acre.

The Kaskaskia loam, covering 24,576 acres, or 7.8 per cent of the area, occupies large tracts in the bottoms of the Kaskaskia River and larger tributary streams, is subject to annual overflow, except where diked, and has a water table within 3 feet of the surface during the greater part of the year. The soil is very fertile, and its texture is favorable to both easy drainage, which is necessary, and easy cultivation. Broad, open ditches are generally employed in draining areas of this type. Two-thirds of the soil is covered by an open forest of oak and water maple. It produces about 50 bushels of corn, 50 bushels of oats, and 25 bushels of wheat per acre. Good crops of clover and timothy hay are also secured.

Edgerton silt loam, covering 9,920 acres, or 3.2 per cent of the area of the county, occurs in the upland, occupying the morainal hills already referred to. These hills are rarely more than 125 feet higher than the surrounding prairie, the differences being usually enough to give the type better drainage than any other soil in the county. Owing to its position on slopes care is often necessary to prevent gullying. The soil has been derived from a peculiar phase of the loessial material. Hardpan does not occur in this type, and corn and clover and other deep-rooted plants do better than on the other prairie soils. Wheat yields from 15 to 20 bushels per acre, corn from 25 to 35 bushels, oats about the same as corn, and hay about 1 ton. Many apple and peach orchards are growing upon this soil and are thrifty and productive where proper care is given them. The type is also adapted to the production of grapes, cane fruits, and strawberries.

The Yazoo clay, covering 5,376 acres, or 1.7 per cent of the area, occupies small depressions in the broader bottom lands. The soil is poorly drained, and very little of it is cultivated.

The Yazoo sandy loam, covering 2,176 acres, or 0.7 per cent of the area, is found along the front lands of the Kaskaskia River, particularly along the larger bends. The type is used for corn, from 30 to 45 bushels per acre being produced. If properly diked it would be adapted to truck crops.

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ST. CLAIR COUNTY AREA, ILLINOIS.

St. Clair County lies west from Clinton County and just across the Mississippi River from St. Louis. It has an extent of about 650 square miles, or 415,872 acres. Fertile soils and the near market of a great city have combined to make this one of the leading agricultural counties in the southern part of the State.

The surface of St. Clair County is varied, comprising prairies, hills, and bottom lands. The greater part is occupied by prairies and hills making up the upland, but there are wide areas of bottoms along the Kaskaskia and Mississippi rivers. From the latter the "Great American bottoms" extend back a distance of 8 miles at the northern boundary. Bluffs are usually found between the bottom lands and the upland, and are especially pronounced along the Mississippi. They commonly consist of the loess overlying the glacial débris, but from a point 3 miles south of Centerville and extending almost to Monroe County they are formed of an almost perpendicular wall of limestone, 100 feet high, capped by 6 feet of glacial débris and then by 50 to 100 feet of loess.

The geological formations of St. Clair County comprise the Quaternary part of the lower Coal Measures, and about 300 feet of the Subcarboniferous limestone. These rocks are covered with a glacial deposit, varying from a few feet to 125 feet in thickness, and rarely outcrop. Though no unweathered loess was found in the area, except along the bluffs, where the deposit in places reaches a depth of 100 feet, it is thought that a thin deposit of this material formerly covered nearly the whole of the upland part of the county, and forms the material from which the surface soils have been derived.

Two coal seams of economic importance occur in the Coal Measures and underlie three-fourths of the county, which is second in coal production among the counties of the State. The one seam worked has a thickness of 6 feet, and has been a source of great wealth to the county.

In general the agriculture of St. Clair County is in a flourishing condition. Improvements on the farms are substantial, and the equipment ample. There is some lack of thrift evidenced by unhoused farm machinery.

About one-half the farms of the county are worked by tenants. Rent ranges from $3 to $5 per acre in general farming to from $8 to $10 per acre where market gardening is followed. Share tenants usually give one-third of the crops. The average size of farms is about 80 acres. Land values average from $20 per acre for the less desirable to $125 per acre for the best soils, well improved. The labor is white and generally efficient, but apt to be scarce during the busy times of harvest. Wages by the month vary from $15 to $20, with board and washing in addition.

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Wheat, corn, oats, Irish potatoes, orchard fruits, truck, and market-garden crops are the most important products of St. Clair County. Of these wheat is by far the most important, occupying two-thirds of the cultivated area. Irish potatoes form a very profitable crop in the bottom soils. There are many small orchards in the area, but in a commercial sense fruit growing in St. Clair County is in its infancy.

The Miami fine sandy loam, covering 138,560 acres, or 33.3 per cent of the area, is found along the bluffs, from which it extends back into the uplands from 5 to 15 miles. It occurs in broad areas, broken somewhat by smaller areas of Miami silt loam. The surface is rolling to hilly. The soil has good drainage. It has been derived from the loess, a material rich in lime, magnesium, iron, aluminum, and potash, which are given up gradually upon weathering of the soil particles. This gives a soil of lasting fertility, but encourages improvident methods of agriculture.

Wheat, corn, oats, hay, Irish potatoes, orchard fruits, and market-garden crops are all grown on this soil type. Probably one-half the area is devoted to wheat, which yields on the average about 15 bushels per acre. Corn yields 35 bushels, oats the same, hay from 1 to 1½ tons, and potatoes about 75 bushels per acre. The best farmers secure much larger yields. All kinds of fruits do well, and there is excellent opportunity for developing this industry.

The Miami silt loam, covering 106,432 acres, or 25.6 per cent of the area, occurs in a broad, extended area in the northeastern part of the county in a large area known as Ridge Prairie, near O'Fallon, and in smaller areas southwest of Belleville, south of Freeburg, and west of Marissa. The surface is level to gently rolling. The type occupies slight depressions, probably the basins of old shallow lakes, since drained by erosion and changed into wet, grassy prairies. Before cultivation it is necessary to complete the drainage by ditching. The soil is composed of weathered loess mingled with decaying vegetable growth native to swampy areas. It is the best of the upland types for general farming purposes. Wheat is the chief crop, a yield of 40 bushels per acre being sometimes secured, but 18 bushels probably represents the average yield. Corn, second in importance, yields about 40 bushels per acre. From 1 to 2 tons per acre of clover and timothy hay is secured. Potatoes are grown to considerable extent, yielding 75 bushels per acre. A more systematic rotation of crops is recommended in place of the too-constant growing of wheat.

The Marion silt loam, 86,464 acres, or 20.8 per cent of the area, covers a large tract in the southern part of the county. The surface ranges from level and gently rolling prairie to rolling and hilly, the greater part of the area having the last two characteristics. The subsoil of this type is locally known as hardpan, and, occurring as it does at an average depth of 15 inches, has great influence on the crops.

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This type is recognized as a poor type for general farming. Wheat does better than the other grains, and this crop occupies probably 75 per cent of the cultivated area. The average yield does not exceed 12 bushels. Corn gives poor returns. Apples, pears, peaches, and strawberries thrive and might be made much more profitable crops than wheat. Fruit trees seem to be able to penetrate the hard subsoil and thus are less affected by the droughty conditions prevailing in this type during the drier months.

The Yazoo clay, covering 26,944 acres, or 6.5 per cent of the area, occupies a large part of the American bottoms in St. Clair County. It is an exceedingly fertile soil of heavy texture and level surface. Alluvial in origin, it lies not far above mean water level, and there are large areas too wet and swampy for cultivation, while all the areas would be benefited by underdrainage. In the low-lying areas it would be necessary to raise the drainage waters by means of pumps, but the fertility of the soil and its proximity to St. Louis would make reclamation profitable even by this expensive method. Wheat, oats, corn, and hay are the principal crops. Wheat produces about 15 bushels, corn 50 bushels, oats 35 bushels, and hay 1 to 1½ tons per acre. Wheat has a tendency to winterkill. Damage from this cause could be lessened by underdrainage. Formerly this soil was occupied by heavy forests, with intervening prairies, but it is to-day almost all cleared. Uncleared areas are used for pasture.

The Waverly silt loam, covering 25,152 acres, or 6 per cent of the area surveyed, is not a very important soil. It occupies areas along the smaller streams and the higher ground at the foot of the bluffs bordering the Kaskaskia River. The areas are usually flat and subject to overflow. The greater part of them are uncleared, the proportion under cultivation being larger along the small than along the larger streams. Drainage conditions govern this distribution. Hay and corn are the chief crops and on the best drained areas in favorable seasons the yields are about the average for the county.

The Yazoo sandy loam, covering 12,800 acres, or 3.1 per cent of the area, occurs principally on the front lands of the Mississippi River. Almost all the different crops grown in the county are planted on this soil, but it is too light and sandy to give the best results with general farm crops. It is well adapted to trucking and market gardening, and near St. Louis considerable areas are used in this way, but there is room for an extension of this industry.

The Kaskaskia loam, covering 9,664 acres, or 2.3 per cent of the area, is a rather heavy loam occurring in the low, alluvial bottoms along the Kaskaskia River. The surface is generally level, but somewhat broken by bayous and lakes. The entire area is subject to overflow. Nearly all the type is covered by forests, and only a few higher-lying areas are cultivated. The soil is naturally fertile and, if pro-

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tected from overflow and provided with proper drainage, could be very profitably tilled.

The Lintonia loam, covering 5,696 acres, or 1.4 per cent of the area, occurs as narrow bands along the foot of the Mississippi River bluffs. It has been formed by wash from the bluffs and uplands, or by deposition in fan-shaped deltas by streams issuing from the upland. The soil being derived from loess is fertile and easily cultivated. Corn, wheat, oats, hay, Irish potatoes, truck, and market-garden crops are all grown. Corn yields as high as 50 bushels per acre, but the soil is best adapted to truck and market-garden crops, and should be used more generally in that industry. Irish potatoes yield 200 bushels per acre.

The Yazoo loam, covering 4,160 acres, or 1 per cent of the area, is another bottom soil. The largest areas occur south and southeast of Cahokia. The type usually occupies higher-lying areas or low, broad ridges. The surface is slightly rolling, usually well drained, and not subject to overflow except during the highest floods. Corn and wheat are the principal crops. Truck is grown to a limited extent.

The adaptation of soils to crops has been worked out in a broad, general way. Experience has shown that the Marion silt loam is ill-suited to corn and that it produces wheat better than any other grain, while the Yazoo sandy loam is recognized as the best soil for truck crops. The agricultural condition of the county will be materially improved by the further specialization of the soils suited to market gardening and by extension of the fruit industry on those types that give indifferent results in the production of wheat.

CLAY COUNTY AREA, ILLINOIS.

Clay County is situated in the southern central part of the State, about 100 miles directly east of St. Louis. It contains 294,336 acres, or about 460 square miles. The surface of the county is that of a broad, level plain, through which the streams have carved valleys from a few to 50 or 75 feet deep. The Little Wabash River crosses the county in a generally southeasterly direction, and with its tributaries forms the natural drainage system. The physiography near the stream is hilly and broken, but beyond the influence of more rapid erosion the surface is a level to gently rolling prairie. The basal rocks underlying the county belong to the Upper Coal Measures. They are sandstones, sandy black shales, and limestones. Some thin seams of coal occur, but they are not of commercial importance. The underlying rocks have very little direct influence on the soils, which are derived from a deposit of glacial drift varying in thickness from 10 to 40 feet. The drift consists of a hard, bluish clay stratum, locally called hardpan, resting beneath a gravelly, sandy, silty till,

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the percentage of gravel and sand decreasing toward the surface until it is lost at a depth of from 4 to 6 feet.

The leading agricultural industries are fruit growing and general farming. Within the last twenty-five years Clay County has reached the front rank among the apple producing counties of the United States. In 1883 the shipments amounted to 17,042 barrels, while 272,770 barrels, with a value of $281,485, were produced in 1892. The area in orchards has risen to 30,000 acres. This and dependent industries have done much to improve the conditions of the farming classes, formerly engaged in the almost exclusive production of grain, to which a very large part of the soil of the county was not particularly adapted. Corn and wheat are still important crops, but the former does not do well on the prairies. Hay is also largely grown. Timothy is the leading grass, but large areas are devoted to redtop, both for hay and seed. More stock is being kept than formerly, an important matter where soils have been exhausted.

The Marion silt loam, covering 260,544 acres, or 88.5 per cent of the area, occupies practically the whole of the upland or prairie region. The surface is level or gently rolling, except near the streams, where it is somewhat hilly or broken. The soil is a fine, silty loam, containing a large percentage of silica, becoming hard when wet, but falling into a crumbling, floury mass when cultivated. The soil grades into a clay subsoil, but between soil and subsoil there is usually a thin stratum of white siliceous sand and silt, locally called hardpan, though not so firmly consolidated as a true hardpan. This stratum has great influence on the crop value of the soil, interfering with root extension and with the maintenance of proper moisture conditions during dry weather. For this reason the soil is better adapted to winter wheat, which is shallow rooted and grows and ripens during the part of the year least likely to be droughty. Corn, on the contrary, does not flourish. The discovery that the hardpan did not injuriously affect fruit trees and the development of the apple industry have greatly increased the value of this soil type. Corn produces about 15 bushels and hay three-fourths of a ton per acre. Redtop for hay and seed is an important crop, and the soil seems well adapted to it. The soil is deficient in organic matter, and the keeping of more stock and growing of larger areas of leguminous crops is recommended.

The Waverly silt loam, covering 30,976 acres, or 10.5 per cent of the area, occupies the greater part of the bottom lands of the county. The drainage is poor, and the areas are locally called "water-oak flats." The surface is flat, but intersected by sloughs and old stream channels, which help to carry off the surplus water. The areas are subjected to overflow, but there are few areas that could not be drained artificially. The soil is of alluvial origin, and is composed of material washed from the higher lands, brought down by the streams and

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deposited along their flood plains. Probably 50 per cent of this soil type is still in forest. Corn and hay are the principal crops.

The Yazoo loam occupies about 0.5 per cent of the area, or 1,472 acres. It occurs in small, narrow areas in the Little Wabash River bottoms, and is the best soil in the county for general agricultural purposes, being level, yet well drained, fertile, and friable. Three-fourths of the type has been cleared and brought under cultivation, being used almost exclusively for corn, which yields on the average about 50 bushels per acre. The liability to overflow diminishes the value of this soil somewhat.

The Yazoo sandy loam, covering 1,344 acres, or 0.5 per cent of the area, occurs in small detached areas along the Little Wabash River. Corn is the principal crop, but the soil is best adapted to truck crops or to some crop requiring a soil of light, porous texture.

The upland soils of Clay County have been more or less exhausted by continuous cropping with grain and hay without systematic restoration of plant foods to the fields by rational rotation of crops and the use of green manuring crops and stable manure. There is an evident tendency among the farmers to increase the number of live stock, and to feed more of the grain and forage crops on the farm rather than send such crops to market. If this policy is followed out, it can not but add greatly to the fertility of the soils and indirectly to the wealth of the farmers. The rotation generally practiced does not include a legume and should be modified in this respect. If clover will not succeed, then cowpeas should be substituted. The adaptation of soils to crops has not been carried to any great degree, and corn is still largely raised on the Marion silt loam, although the average yield of only 15 bushels to the acre indicates that the soil is but poorly suited to the cultivation of this crop. The great extension of the apple industry of the county has absorbed 30,000 acres of this poor soil, but this is only one-eighth of the total area of the type. There is thus room for further extension of the industry, an extension going on rapidly at the present time. This is the most important movement in soil adaptation in the county, and seems about the only practical change in the local agriculture as long as the hardpan problem remains unsolved. If some feasible plan can be found to change the conditions of the soil as regards this more or less impervious and consolidated substratum, new possibilities in the use of this soil will be opened up.

JANESVILLE AREA, WISCONSIN.

The Janesville area comprises 450 square miles of territory in Rock and Dane counties, extending from the Illinois State line (42° 30′) to parallel 43° north latitude. The important manufacturing cities of Janesville, Beloit, Edgerton, and Stoughton lie within the area. The

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physiography of the country is typical of a glaciated area where neither glacial erosion nor deposition has entirely obliterated pre-Glacial topography. The surface is a succession of low, rounded hills and ridges, interspersed with broad, flat valleys and stretches of level prairie. The elevation ranges from 740 feet near Beloit to over 1,100 feet on the highest hills. The Rock River and its chief tributaries, the Yahara and Turtle rivers, are the principal streams forming the drainage system. They also furnish considerable power, which is utilized by manufactories. Small lakes and ponds are scattered throughout the area. The basal rocks have little or no influence on the soils, which are derived from glacial drift.

The agricultural industry of the Janesville area is closely linked and prospers with the flourishing manufacturing industries of the cities of the region. Tobacco is the chief special crop, and Janesville, Edgerton, and Stoughton are prominent centers of the Wisconsin binder leaf tobacco trade. There are canneries handling sweet corn, cucumbers, and cabbages, the production of which is steadily increasing, and there are many other manufactories depending considerably upon the agriculture of the region for the support of their employees.

The average size of farm is about 114 acres, the average value including improvements other than buildings, $5,250, while the average value of buildings is $1,550. The average value of farm products not fed to cattle is $1,137 per farm annually. Eighty per cent of the farms are operated by the owners or by salaried superintendents. The majority of the farms are devoted to general farming. The greater number maintain small herds of dairy cattle and some beef stock. Dairying is on the increase. Many flocks of sheep are found. Corn, hay, oats, rye, barley, potatoes, and tobacco are the principal crops. Tobacco was introduced into Wisconsin in 1858. A Spanish binder derived from West Indian seed is grown. About 80 per cent of the leaf is suitable for binder use on cigars, 5 per cent is thin enough to be used for wrappers, while the remainder is chiefly used as filler. The yield is 1,300 pounds per acre, averaged for the whole area, and the price per pound to the farmer is about 6 or 7 cents. The tobacco fields are fertilized with barnyard manure, practically no artificial mixtures being used. In spite of the liberal use of manure, it is noticed that the newly cleared fields give better yields than those in cultivation for some time.

Owing to the practice of general farming there is merely a broad recognition of soil adaptation, without much practical working out of crop relationship. All the crops are grown on all the soils. The sandy soils should be used for certain truck crops, and the heavy muck areas, when drained, will be valuable for the production of cucumbers, onions, cabbages, and celery, and should aid the development of the canning industry already established in the area.

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The Janesville silt loam, covering 81,344 acres, or 28.2 per cent of the area, is one of the most fertile soil types of the region, forming the larger part of the rolling prairie of southern Wisconsin. The surface is uniformly well drained by many small streams. From 50 to 60 bushels of corn are produced per acre, from 40 to 50 bushels of oats, about 1½ tons of hay, and 1,200 pounds of tobacco. In general, this type is only less desirable for general farming than the Janesville loam of the Rock Prairie. It is too heavy a type for the production of wrapper tobacco, but produces a good quality of binder leaf.

The Edgerton silt loam, covering 81,216 acres, or 28.2 per cent of the area, is a lighter soil than the Janesville silt loam. It occupies the hill country in southern Rock and Plymouth townships, alternating in broad bands with the Janesville silt loam. The soil has fairly good drainage, but requires tile drainage to secure the best results. Derived from glacial material, it more nearly approaches the typical till than any other soil of the area. The areas are frequently interrupted by long, narrow ridges and oval, conical hills of gravel and bowlders, and many erratics are scattered over the surface. Many kettle holes pit the surface, and these frequently contain water during the entire year. The area originally consisted largely of oak openings, and the most of the oak forests of the area are now found on this type. From 45 to 50 bushels of corn, 40 bushels of oats, 1 to 1½ tons of hay, and 1,100 or 1,200 pounds of tobacco are about the acre yields on this soil.

The Miami loam, covering 51,968 acres, or 18 per cent of the area, is a well-drained, warm, friable soil. It is about evenly divided between level prairie and rolling hill country. The soil does not contain a high enough percentage of clay, nor does it possess a deep enough subsoil, to make it a good soil in dry seasons. The average yield per acre of corn or oats is about 40 bushels, while 1 to 1½ tons of hay is secured. The yield of tobacco is about 1,100 to 1,200 pounds per acre. The crop of 1902 seemed to be nearer a wrapper leaf than any other produced in the area. The ordinary crops suitable for canning could be advantageously produced on this soil.

The Meadow, covering 18,112 acres, or 6.3 per cent of the area, consists of poorly drained areas lying along stream courses, near the margins of lakes, or in the extensive depressions once containing lakes. The texture of the soil varies. At present this type furnishes large quantities of coarse hay. Many areas could be reclaimed through the use of tile drain, and would then make excellent corn land.

The Afton fine sandy loam, covering 16,256 acres, or 5.6 per cent of the area, is found near water level along Rock River and its principal tributaries, but the largest areas occur between Rock River and Sugar River, along the State line. The great part of this type consists of gently sloping or nearly level fields, usually well drained and easy to cultivate. The soil is derived from deposits laid down by small

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streams issuing from the glacier front, though some small areas have been accumulated through rain wash from the Miami loam. In texture the soil approaches more closely the truck soils of the Atlantic Coastal Plain than any other of the types in the area, although it is more loamy and not so coarse as the typical truck soils. The yields are medium. The average yield per acre of corn is about 30 bushels, of oats about the same, of hay about 1 ton, and of tobacco about 1,100 pounds. The leaf on this type is thinner and of better texture than where the yield is heavier. It seems to be the type nearest the soils used in the East for wrapper tobacco.

The Hanover sand, covering 11,648 acres, or 4 per cent of the area, occurs in two main areas in Plymouth and Newark townships. It has been derived from the wash from the Afton fine sandy loam or by the erosion of the Miami loam, leaving the subsoil of that type at or very near the surface. There is a small percentage of fine gravel mixed in the surface soil. The crop yields are below the average. The soil is too sandy to produce well except in extremely wet seasons. Except on newly cleared areas, the yield of tobacco is not more than 1,000 pounds per acre, although the quality is good. The soil needs organic matter, and will be greatly improved by methods tending to supply this deficiency.

The Muck, covering 10,368 acres, or 3.6 per cent of the area, occurs chiefly along stream courses, in many cases being surrounded by areas of meadow. In other locations soils of this general type are worth when reclaimed from $100 to $200 per acre. They are best adapted to onions, celery, cabbages, and cucumbers. The type is little used in this area.

The Mackinaw gravel, covering 9,024 acres, or 3.1 per cent of the area, is a coarse gravelly soil and subsoil, occurring as outcrops of bands of gravel along the stream courses or as knolls and ridges of glacial débris. This type is used chiefly as pastures, its texture and steep slope making it unfit for general cultivation. The type might be profitably used for grapes.

The Janesville loam, covering 6,656 acres, or 2.3 per cent of the area, is the principal type found on the Rock Prairie. It occupies both banks of the river near Janesville and attains its greatest development beyond the eastern border of the area mapped. The surface is almost uniformly level. The drainage is good, being assisted by the gravel lying beneath the subsoil. This soil is esteemed for the production of grain. The average yield per acre of corn is about 60 bushels; of oats, about 45 to 50 bushels; of barley, about 40 bushels. Hay produces about 2 tons per acre. The average yield of tobacco is about 1,400 pounds. A first-class grade of binder leaf is produced. This was one of the first soils to be brought under cultivation. It has maintained a high degree of fertility from 1835 to the present time.

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The Miami black clay loam, a most important and fertile soil in States farther east, covers only 1,856 acres, or 0.7 per cent of the total area of the Janesville area. All the bodies of this soil are found closely associated with Meadow and Muck. The process of formation has been the same in all three types, differing only in degree. By drainage wide areas of Meadow and Muck could be added to and classed as this soil type. When drained this is a typical corn soil.

DUBUQUE AREA, IOWA.

The Dubuque area comprises about 440 square miles, or 281,664 acres. It is situated in the east-central part of Iowa, covering parts of Dubuque and Jones counties, Iowa, and Jo Daviess County, Ill. The Mississippi flows across the northeast corner. Dubuque, a city of about 40,000 population, lies within the area. Other important towns are Farley and Cascade. The surface of the area is rolling and hilly, being rougher and more broken along the river. The elevation ranges from 600 feet at the Mississippi to 1,200 feet on the divide 10 miles west. To the east short streams flow directly into the Mississippi River; to the west the streams flow into the Maquoketa and its tributary, the North Fork, finally reaching the Mississippi also. The basal rocks of the area are the Galena and Niagara limestones and the Maquoketa shales, but these have little influence on the soils, 90 per cent of which are derived from loess. The area has been subjected to two periods of glacial action, and between the rocks and loess there is a layer of glacial drift. This enters directly into the formation of some of the soils.

The chief agricultural products of the Dubuque area are corn and hay, which are largely fed to cattle, hogs, and sheep. The tendency of the live-stock industry during the last fifteen years has been more and more toward dairying, the butter being manufactured in creameries. Wheat was formerly the most important crop, and the interest in its production is being revived. Barley is not grown as extensively as formerly. The agricultural classes are in a fairly prosperous condition. A large proportion of the farmers are of foreign parentage, and their thrift and industry have built up a profitable system of farm practices. The farms range in size from 150 to 600 acres on the more level uplands and from 100 to 400 acres near Dubuque. The value of agricultural lands ranges from $40 to $80 per acre, and is increasing from year to year. The farms are operated largely by the owners.

The Miami silt loam, covering 176,896 acres, or 62.8 per cent of the area, occurs in one unbroken body extending from one boundary of the area to the other. The surface is rolling and hilly and made up of a system of small divides developed by stream erosion. The drainage is good, but the soil holds water well and withstands protracted

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drought. It is friable and fertile and especially adapted to the production of grain and grass. Its worst feature is a tendency to "heave" in winter, and on the steep slopes it washes badly. Corn is now the principal crop, the yield per acre ranging from 25 to 80 bushels and averaging 45 bushels. Wheat was formerly the important crop, but since the introduction of stock raising this crop has been generally abandoned. Interest in it is reviving. On the more level areas 40 bushels of oats, 20 bushels of rye, 30 bushels of barley, 18 bushels of wheat, and 1½ tons of hay are about the average yields per acre. While the soil is well adapted to these crops, with the present system of farming there are a number of forage crops—alfalfa, rape, kafir corn, and sorghum, for instance—that might be grown to advantage. The hardier tree fruits are also well adapted to this type, and certain of the berries give good results.

The Clarksville stony loam, covering 60,672 acres, or 21.6 per cent of the area, is composed of rough, rocky slopes and outcrops of limestone rock. The soil is very stony. The interstitial material is composed largely of wash from the loess, but there is some residual clay and sand intermingled with it. The soil has little agricultural value and is used for pasture. Much of it is in forest. Blue grass forms an excellent sod where the slopes are not too steep.

The Lintonia loam, covering 22,272 acres, or 7.9 per cent of the area, is a colluvial soil, occurring along the base of bluffs bordering the streams. It is usually well drained, though in some cases overflowed during floods, and where the areas are large enough they are generally cultivated. It is, as a rule, used for pasturage, but is a very fertile soil, yielding excellent crops of all the grains and grasses. It is well adapted to certain truck crops.

The Miami sandy loam, covering 15,040 acres, or 5.3 per cent of the area, is found entirely in the western third of the area. The surface is rolling. This type is derived probably from deposits of the Iowa glacier. It varies considerably in texture, both in soil and subsoil. The soil is inclined to be droughty, and the yields of grain and grass, the chief crops, are dependent to a great extent upon the rainfall. With proper methods for the conservation of fertility and soil moisture, the growing of truck crops and fruit might be profitably undertaken.

The Meadow, covering 4,160 acres, or 1.5 per cent of the area surveyed, is confined mainly to the lower part of the inner gorge of the Mississippi River. The areas are subject to overflow, and are valueless as far as agricultural use is concerned.

The Miami fine sandy loam, covering 2,624 acres, or 0.9 per cent of the area, occurs along the Mississippi River. The main area lies below the bluff southeast of Dubuque, on the east side of the river, extending a distance of 5 miles along the river bank. The greater part of this

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soil is under cultivation. Grain and grass are crops chiefly grown. It is well adapted to the production of truck. Owing to its light, porous nature the type is apt to be droughty.

In the Dubuque area the chief opportunities for improvement lie along the lines of industry already established. An introduction of better breeds of live stock would increase the profits derived from this interest. A less extensive system of agriculture could also be adopted with advantage, and the substitution of some other legume for clover, which of late years has not done very well, is recommended. Alfalfa might prove suited to the soils and climate.

HOWELL COUNTY AREA, MISSOURI.

Howell County contains 919 square miles, or 588,160 acres, and is situated in the south central part of Missouri, bordering Arkansas on the south. It has a length north and south of 38 miles and a width east and west of 24 miles. This area lies nearly in the center of the extensive plateau known as the Ozark Uplift, which involves almost the whole of Missouri south of the Missouri River and a considerable part of northwestern Arkansas. The part of the plateau situated within Howell County has an elevation above sea level of from 900 to 1,300 feet, with a general slope to the south and east. Through the central part of this area extends a broad divide whose general trend is northwest and southeast. The surface of this plateau is rolling and hilly. Nowhere in the country do there occur very extensive level areas. Along the main divide the country has a gentle swell, which in a few places gives way to comparatively level stretches. Off the divide, along the borders of the county, the country is very rough and rugged. In general the southern half of the county is more level than the northern half. Throughout the area are scattered bowl-shaped depressions of variable extent and depth, known as sink holes, which are formed by the falling in of the roofs of superficial caverns in the limestone. Thorough drainage is attained in every part of the county through a complete system of ramifying streams and ravines. There are no large streams or rivers in the area.

The rocks from which the soils of the region have been derived are of sedimentary origin and belong to the Cambro-Silurian series. These rocks consist of alternating strata of limestone and sandstone, of which exposures 100 feet in thickness have been noted. The geology of the county has never been studied in detail, so that very little information is available on the subject. But three types of soil were found in the area.

The Clarksville stony loam is the first of these in order of extent, occupying 499,264 acres, or 84.89 per cent of the total area. The soil of this type contains from 10 to 65 per cent of chert and sandstone fragments, the chert largely predominating. This soil occurs in every

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part of the county and may be considered as a continuous body of soil, with the other types cutting through it at irregular intervals, or occurring in limited areas in its midst. The surface of this soil type has nearly all the characteristics of the topography of the county in general. It covers all the divides where the most level areas are found, as well as areas along the streams where it is roughest, and includes all the slopes suitable for cultivation to ordinary crops. A large part of this type is covered with forests of black, white, red, and post oak, hickory, and yellow pine. The crops produced on this soil are chiefly the grains and grasses, which are most important in extent and probably in total value, and fruit, which has gained for the region a prominent place in the fruit areas of the United States. The average yields of the grains and of hay are moderate, the yield per acre of wheat ranging from 8 to 10 bushels, that of corn from 15 to 30 bushels, and of hay from 1 to 1½ tons. The yield of rye is about that of wheat, and of oats from 12 to 30 bushels per acre. Cotton is grown to a limited extent in the extreme southern part of the county, but the yield of lint is small, ranging from 150 to 300 pounds per acre. Tobacco finds a place on many farms on this type of soil, but only in small patches, and the product is not of commercial importance. The fruits most extensively grown in the Howell County area are the peach and apple, and the orchards are limited almost entirely to the Clarksville stony loam. The fruit is uniformly of large size and superior quality, while the color is especially attractive. Pears, plums, strawberries, blackberries, and raspberries are also grown. Grapes of all kinds thrive on every part of this type and are generally considered to be the best adapted to the soil of any of the fruits grown. Considering the type as a whole, the tree fruits and grapes are better adapted to it than any other class of crops. The soil is not suitable for crops making a heavy draft on its fertility each season, and, if the grains are to be grown, care must be taken to maintain and increase the supply of available plant food.

The Clarksville loam covers 48,512 acres, or 8.25 per cent of the area. It is distributed throughout the area in narrow ribbons along the streams where they have any considerable width of valley. It constitutes the "bottom-land" type of the area. This soil contains few rock fragments of any kind. It is practically all cleared and is almost entirely under cultivation. The soil is generally well drained, but has strong drought-resisting properties. These bottom lands are the best general farming lands in the county. Upon them all the grain crops give good returns. The yield per acre of wheat ranges from 12 to 22 bushels, of corn from 30 to 50 bushels, and of hay from 1 to 2 tons. Other crops grown give equally good returns. The small fruits do remarkably well on these valley lands. The blackberry, raspberry, currant, and strawberry are chiefly grown and are

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of excellent quality. The apple orchards are longer lived and yield more abundantly on the bottom soil than on the hill soil, but the quality of the fruit is not so good. Among the truck crops the sweet potato is found to produce very well.

The Clarksville silt loam covers 40,384 acres, or 6.86 per cent of the area. It differs from the Clarksville stony loam chiefly in the absence of rock fragments. The drainage is generally good, and because of the absence of rock this type is more easily cultivated than any other in the area. The crops grown are about the same as those on the Clarksville stony loam, and the yields are generally about the same, except that the yield of wheat is probably somewhat larger.

Taken as a whole, the farming classes in this area are not in a very prosperous condition. The county has not yet recovered from the effects of the severe drought of 1901. Little modern farm machinery is used, largely because of the rough and stony character of so much of the soil. Not enough attention is paid to rotation of crops, nor to improving the fertility of the soil. It is believed that the substitution of stock raising and dairying for grain farming would be beneficial and yield larger returns. In the fruit industry the conditions average better than in general farming. In the county there are between 10,000 and 20,000 acres in orchards, mostly peach and apple. The fruit industry is somewhat hampered by high freight rates and poor county roads.

STUTTGART AREA, ARKANSAS.

The area surveyed lies wholly within Arkansas County and comprises an area of 251 square miles. It includes the towns of Stuttgart, Dewitt, and Almyra. These are all small, the largest, Stuttgart, having a population of something more than 1,200.

The soils of this area exhibit a marked uniformity. Seemingly they all belong to one formation, and the deposits from which they are formed were laid down on the ocean's floor at the time of the submergence of the eastern half of the State under the Eocene-Tertiary sea. The area surveyed is divided into nearly equal areas of prairie and of forest land. The surface of the prairie section is level, while the forest area is rolling but not rugged. Drainage on the prairies is poor, but the forested areas have efficient drainage. No rocks of any kind are exposed within the area. The soils proper are from 3 to 4 feet deep, and the underlying clay and sand have been penetrated to a depth of 110 feet without striking rock.

Not much diversity exists in the agricultural products of the area. The raising and fattening of cattle is one of the principal industries. The cattle are low grade and of mixed breeds. There is one creamery, but very little dairying is carried on. A large amount of wild hay is cut, baled, and shipped to outside markets. A large acreage is devoted

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to winter oats, which are of fine quality and yield heavily. Very little wheat is grown. Some corn is grown, and the acreage is increasing. Cotton is grown to some extent, but is not an important crop. Three types of soil are found in the Stuttgart area.

The most extensive soil type is the Miami clay loam, which covers 69,696 acres, or 43.3 per cent of the total. This soil is found scattered about throughout the prairie section of the area wherever drainage is most effective. It is best developed, and to the greatest extent, in the northern and northwestern part of the area. The areas of this soil appear quite level and flat, but there is enough fall to carry off surplus surface water. The soil is naturally rather porous and except in times of excessive rainfall the drainage is adequate. Oats and corn are the crops principally grown. Oats average from 30 to 50 bushels to the acre, and corn from 25 to 40 bushels. The grasses native to this soil furnish good pasturage and large yields of hay.

The Almyra silt loam covers 63,104 acres, or 39.3 per cent of the area. It is a rather loose, silty soil, with a generally level surface and poor drainage. Only a small percentage of this soil is in cultivation. When the season is not too wet good yields of oats, corn, cowpeas, sorghum, and kafir corn are secured. Prairie hay is the most important product of this type, the average yield being 3 tons to the acre. This soil needs underdrainage, the installation of which would convert the type into a fertile, productive soil.

The Guthrie clay, covering 27,904 acres, or 17.4 per cent of the area, is the least important of the soils. It is found in the low, poorly drained woodlands in the northern part of the area. The forest growth upon this soil is of very little value for lumber. Because of lack of drainage this soil has no agricultural value. It is not cultivated at present, nor is it likely soon to be, except possibly in the areas along the bayous, which are so situated as to be readily drained.

The soils of the area are so similar that when the moisture conditions are the same crops show little preference for one over the other of the two arable types. Not enough attention is paid to diversity of crops, nor to the supplying of home demands. Though there is a large quantity of pork consumed in the area, and although there is abundance of acorns and other mast in the timbered areas, very few hogs are grown. The native grasses in places show signs of exhaustion, and should be replaced by tame grasses and clover. The cattle should be improved by the introduction of thoroughbred sires.

WICHITA AREA, KANSAS.

The Wichita area comprises the southern half of the Wichita sheet of the U. S. Geological Survey, and embraces approximately 465 square miles. It includes over 300 square miles in the southern part of Sedg-

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wick County and about 150 square miles in the southwestern part of Butler County. Wichita, the county seat of Sedgwick County, is the third city in size in the State, and is a thriving community with a population of about 25,000.

The area embraced in the Wichita sheet lies at an elevation of from 1,250 to 1,400 feet above sea level, and in topography is a rolling prairie. The greater part of the upland is marked by low, smoothly rounded, and gently undulating, billowy ridges or crests, the tops of which are seldom more than 20 feet above the troughs of the swells. These swells are from a few hundred yards to half a mile or more apart, usually follow approximately parallel lines, and generally trend in a direction slightly west of north and east of south. A prominent feature of the physiography is the Arkansas River Valley, which crosses the western part of the area in a south-southeasterly direction. It ranges from 4 to 6½ miles in width, and comprises about 85 square miles of land surface. Next in size to the Arkansas River are the Little Arkansas and Walnut rivers. Cowskin, Fourmile, and Eightmile creeks and Whitewater River complete the drainage system of this area. The uplands are drained by numerous "draws" or shallow ravines, which carry off surplus water in times of heavy rainfall.

The Permian or Permo-Carboniferous is the most extensive and important formation in the area. The bed rock is quite thickly covered with residual soil, and consists of a soft, yellowish to grayish limestone interbedded with light-colored shales. This stone hardens upon exposure to the air and forms a useful building material. On the west side of the Arkansas River Valley, especially in the northern part of the area, unconsolidated material of the Tertiary era is found to be extensive. This material ranges in consistency from a clayey sand to a sandy clay. The actual contact between this Tertiary formation and the Permian was discovered in but one or two places. Along the Arkansas River, south of Wichita, well-defined exposures of loess are found. South of Derby, at the extreme edge of the area, it attains a thickness of about 40 feet. The loess is heavy in texture, and the soil which it forms so closely resembles the residual soil of the limestone that its influence is not perceptible for a much greater distance than 3 miles from the river. A few exposures of a dark slaty-gray impure gypsum are found on the upland a few miles east of Wichita. This mineral is not present to such an extent as to greatly influence the soils.

The soil of greatest extent in this area is the Sedgwick clay loam, which covers 136,320 acres, or 45.8 per cent of the total. It is a friable, silty loam, with an average depth of 9 inches. The greatest extent of this soil is found in the eastern third of the area, on a high, rolling prairie. It is well drained, and in only a few instances, on flat hilltops, is artificial drainage necessary. The soil is derived from the weather-

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ing of the Carboniferous limestones and shales. It is well adapted to the production of corn and wheat, the average yields of the former being about 20 bushels per acre and of the latter about 15 bushels. The soil is not adapted to alfalfa, but kafir corn does well and is extensively grown. Fruit trees do well and yield abundantly.

The Sedgwick loam, covering 47,040 acres, or 15.8 per cent of the area, is a fine, mellow reddish-brown loam to a depth of 10 inches. It is friable and easily cultivated. The type is principally found in the northwestern part of the area. In topography it is a slightly rolling prairie, and it is in general well drained. The soil is derived from an unconsolidated material consisting of clay and sand of Tertiary age. It is a strong soil and is suitable for corn, wheat, oats, kafir corn, etc.

The Arkansas loam is of almost equal extent with the Sedgwick loam, covering 45,568 acres, or 15.3 per cent of the area. It is a very dark brown loam, fine grained and mellow, and has a depth of about 10 inches. The soil is found in a typical state of development in the Arkansas River Valley, in the city of Wichita, and vicinity. It is also present along nearly all the streams in the area. The soil is alluvial in origin, having been brought down as a river sediment and deposited in its present position. It occupies a level position from 6 to 15 feet above the streams, and a part of it is inundated almost every year. Artificial drainage is necessary in some localities. The ordinary farm crops do well on this soil, though wheat is not grown to such an extent as upon the upland. The soil is well adapted to alfalfa. Potatoes and other vegetables do well, grapes give excellent yields, and other fruits are grown with profit.

The Derby loam covers 20,416 acres, or 6.9 per cent of the area. It is a friable, mellow yellowish-brown to reddish-brown silty loam, containing a very small proportion of very fine sand. The soil is easily cultivated, does not bake or clod, and has excellent drainage. It is an upland soil and is found typically developed along the east bank of the Arkansas River south of Wichita. It is derived from the weathering of a fine, compact loess deposit overlying the Permian limestone. It is one of the best soils of the area for general agricultural purposes, being an excellent wheat and corn land.

The Miami sand is of almost equal extent with the Derby loam, covering 19,392 acres, or 6.5 per cent of the area. It is a loose yellowish-brown sand. This soil occupies the western side of the Arkansas River Valley and occurs as a strip from 1 to 2 miles wide and about 14 miles long. The drainage of the soil is perfect, except for a small part of it lying adjacent to the Big Slough, in Delano Township. The Miami sand is derived from material transported by the Arkansas River. Much of this material was probably derived from deposits of Tertiary age. The soil is adapted to corn, alfalfa, and fruit.

The next soil in extent is the Miami fine sand, which covers 15,744

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acres, or 5.3 per cent of the area. It is a rather loose brown sand, medium to fine in texture. It occurs immediately along the banks of the Arkansas River, the larger area lying on the western side. The surface is usually flat, except for the occasional occurrence of low sand dunes. No artificial drainage is required because of the proximity to the river and the natural porosity of the soil and subsoil. This soil is formed by the deposition of river sediments. It is especially well adapted to truck raising and is a good melon and fruit soil. Some corn and wheat are grown upon this soil, but its greatest capabilities lie in the direction of market gardening.

The Sedgwick black clay loam covers 5,568 acres, or 1.9 per cent of the area. It is a fine-grained, black, silty loam. This soil occupies flat or basinlike depressions in the upland prairie and is best developed in the southwestern part of the area. It has no adequate drainage. The soil has been formed from the washing down of the finer particles of silt and clay from the surrounding upland soils. It is generally left for pasturage, though thorough drainage converts it into land well adapted to wheat and corn.

The Clarksville stony loam covers 4,352 acres, or 1.5 per cent of the area. It is a silty, loose-textured soil, found scattered about in small bodies in the eastern part of the area. It occupies high ridges, and especially hillsides along streams and ravines. It is derived from the degradation of limestone of the Permian formation. It is usually too thin and stony to have much agricultural value, but makes good pasture land. The cherty phase of this type would doubtless make a good fruit soil.

The Sedgwick sandy loam covers 3,136 acres, or 1 per cent of the area. It is composed of fine to medium sand, is friable and easily cultivated, and is well drained. It occupies a high, gently rolling position on the upland, and is derived from the weathering of unconsolidated deposits of Tertiary age. It is adapted to corn and wheat and other grains. Fruit does well upon it, and it should prove a good soil for the culture of potatoes and farm vegetables in general.

So far as the production of corn, wheat, oats, kafir corn, and the general farm crops is concerned, but little attention is paid to the adaptation of soils to crops. Corn does better in the bottoms in a dry year, but in a season of good rainfall the uplands produce quite as heavy crops of corn as the lowlands. Alfalfa is not grown to any extent upon the uplands, owing to the impervious subsoil of the upland soils and the inability of the roots to reach a moist subsoil. In the river and creek bottoms the soils are generally lighter and looser in texture, and the alfalfa roots frequently grow downward until they reach sheet water. Fruit does better in the bottoms than on the uplands, but it is believed that the practice of subsoiling would enable fruit to be grown on the uplands. The lighter, sandier soils of the

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bottoms are recognized as being the best adapted to the growing of garden and truck crops.

This area is a typical grain and cattle country. Corn and wheat are the principal farm crops and are planted, cultivated, and harvested almost entirely by machinery. Not enough attention is paid to dairying. The only obstacle to successful and remunerative dairying in this area is the drying up of pastures during the hot, dry season. This, however, is readily obviated by growing kafir corn and sorghum and cutting them green for silo storage. The fruit industry is not yet as fully developed as it should be. The bottom lands are admirably adapted to fruit growing. The trees now growing upon these soils are thrifty, yield prolifically, and do not seem to be troubled to any great extent by insect pests. The growth of truck and garden crops will be stimulated by the erection of a canning establishment in Wichita, plans for which are now under way. It is believed that investigations now being made will show that the bottom soils are adapted to the growth of sugar beets.

GRAND FORKS AREA, NORTH DAKOTA.

The area surveyed is situated in Grand Forks County and covers 314 square miles, or 200,960 acres. The area is 34 miles long and is 6 miles wide for 15 miles west from Grand Forks. For the remaining 18 miles it has a width of 12 miles. The Red River of the North forms the eastern limit of the area.

The topography of the area is very simple. A level alluvial area extends from Grand Forks westward to within about 2 miles of Emerado. From there westward to the glacial drift there are 8 or 10 beaches or ridges with a northwest to southeast course, and from the most westerly of these beaches to the limit of the area extends the glacial drift, a region consisting almost entirely of small hills and hollows scattered about indiscriminately. There are many glacial bowlders strewn about these hills. There are a number of stream courses traversing the area in a general easterly direction. With few exceptions these are dry during the greater part of the year. The area surveyed includes a part of the bed of glacial Lake Agassiz. It traverses the lacustrine deposits in the middle of the valley, the bench lands and beaches westward, and the upper beach of the lake, and extends several miles into the glacial drift. A large number of local beds of crystalline gypsum were found in the lacustrine deposits at a depth of from 1 to 6 feet, and apparently similar beds were also found in the glacial drift.

There are five types of soil in the area, the first in order of extent being the Miami sandy loam, which covers 68,800 acres, or 34.3 per cent of the area. This soil is found on the higher lying areas in the

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western and middle parts of the area, excepting the glacial drift area. The large glacial bowlders commonly found on the other types are usually absent from this one. This is the only type in which gypsum beds were not found at some depth. This soil type is well drained and free from alkali, and is generally well adapted to wheat, oats, flax, and barley.

The soil of next largest extent is the Fargo gravelly loam, which covers 51,136 acres, or 25.4 per cent of the area. The topography is undulating, the type occupying the glacial drift region in the extreme western limit of the area, and the soil is well drained. Local beds of crystalline gypsum are often found at a depth of 2 or 3 feet. Local masses of bowlders are scattered over the surface, but are not numerous enough to seriously interfere with cultivation. A few local alkali spots were found in this soil. The Fargo gravelly loam is largely composed of glacial till or drift, and in the eastern limit of the type the material has been reworked by the wave action of the ancient lake. This soil is adapted to wheat, oats, and barley. The soil on the higher elevations does not retain moisture well and is apt to be affected by drought. Much of this type is still unbroken and unimproved, and such areas bear a splendid growth of prairie grass.

The Miami black clay loam covers 44,352 acres, or 22.1 per cent of the area. This soil is a lacustrine deposit and is the only type in the area that has not been modified by other action since the original deposition. The area occupied by this soil is very level, broken only by a few shallow creek depressions which do not interfere with cultivation. Local beds of crystalline gypsum often occur. There is little alkali in the soil for a distance of several miles west of Red River, but farther west, and especially where the drainage is poor, the amount of alkali is considerable. Excepting these alkali areas, the soil is generally recognized as a good wheat, oats, barley, and flax soil.

The fourth soil in order of extent is the Miami loam, which occupies 17,728 acres, or 8.8 per cent of the area. This soil is found on the slopes of the ancient beaches of the old lake and in intervening areas. The sandy loam surface is due to transportation and deposition of material carried over the beaches by the water during the recession of the lake. The alkali in the first 3 feet is generally less than the minimum limit affecting crops (0.20 per cent), but the subsoil often contains considerable amounts of alkali. The typical areas of this type are well adapted to wheat, oats, barley, millet, and flax, but the lower lying areas, where the alkaline subsoil is near the surface, do not produce very good crops.

The Fargo loam covers 12,352 acres, or 6.1 per cent of the total area. It occupies the slight depressions and shallow swales found in the area of Miami sandy loam, and owes its origin partly to transportation of

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the finer particles from the higher lying sandy loam areas, but chiefly to lacustrine deposits laid down during the early period of the recession of the glacial lake. The drainage is usually good. Small beds of gypsum often occur in the second foot, but there is usually no excess of alkali in the first 3 feet. The soil is well adapted to wheat, oats, flax, barley, and corn.

The last soil in order of extent is the Muck, which covers 6,592 acres, or 3.3 per cent of the area. This soil is found in local depressions, such as kettle holes and swales, and generally along the creek courses and swamps. These areas are usually poorly drained, but there is no alkali in the soil, its absence being chiefly due to the light subsoil. During the summer these Muck areas become dry enough to allow the cutting of the native grasses for hay. Aside from this, no crops are produced on this soil.

The alkali problem is not a serious one in this area. There is generally enough precipitation to prevent the salt in the subsoil from lodging permanently in the surface soil through capillary action, and the roots of the crops commonly grown do not usually, perhaps never, reach deeper than 3 feet. The fact that alkali below this depth, or even at a depth of 2 feet or less, can have little or no effect on the crop growth was conclusively proved by the condition of the crops seen during the survey. The only soils containing injurious amounts of alkali in the first 3 feet are the Miami black clay loam and the valley phase of the Fargo gravelly loam. Good crops of grain, flax, and millet were often found growing on the alkali soils, even where the average amount of salt in the first 3 feet ranged from 1 to 3 per cent.

Irrigation is not practiced in the area, and probably never will be extensively practiced, so that the vertical distribution of the salts will not be affected artificially. As long as the present method of farming continues in the area there seems no probability that the salt in the subsoil will rise over any large area.

In this area little attention is paid to adaptation of crops to soils, any crop being planted on any kind of land. Wheat is by far the most important crop grown, the area devoted to this crop in 1902 being greater than the area of all the other crops combined. In the same year flax was second in acreage. Millet is also grown to a considerable extent. Flax is seldom grown on the same piece of land for more than two consecutive years, owing to a disease known as "flax wilt," caused by a fungus which appears to be introduced with the seed. The crop is grown almost exclusively for the seed, nothing being as yet done with the fiber. The average yield of wheat per acre is about 12 or 15 bushels; barley yields on the average from 25 to 30 bushels, oats from 35 to 40 bushels, and flax about 15 bushels per acre. Very little fruit has been raised or attempted to be raised, the climate being too

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severe for any but the most hardy sorts. Little interest is taken in stock raising except as an adjunct to the economical operation of the farm.

More attention should be paid to a systematic rotation of crops. The breaking up of the large farms in this area, which frequently contain from 1,000 to 5,000 acres, and in one instance even 11,000 acres, and the introduction of diversified farming, dairying, etc., would be a good thing for the country.

BILLINGS AREA, MONTANA.

The Billings area is in the Yellowstone Valley, a little east of the central part of the State, and embraces 107 square miles, or 68,416 acres. It extends from about 1 mile east of Billings to 1 mile west of Park City, a distance of nearly 25 miles. At Billings the area is about 4 miles wide. It gradually becomes wider westward, until at a distance of about 8 miles west of Billings the maximum width of 7 miles is reached. It then suddenly narrows down to about 3 miles, which width is maintained to Park City. The Yellowstone River bounds the area on the south.

The Yellowstone Valley is not a level alluvial valley such as would be formed by a stream in the Mississippi Valley, but consists of a level area from 1 to 1½ miles in width along the river, then a steep and gravelly ridge leading up to an area of level bench land, sloping gently upward away from the river, then a higher bench extending back to the bluffs. The hills surrounding the area are a line of sedimentary ridges rising to a height of from 200 to 500 feet above the valley floor.

The soils of the area were divided into five different types, the first in order of extent being the Billings clay. This soil type covers 17,088 acres, or 25 per cent of the area. This is a clay loam soil, underlain by a tough and sticky clay. Its surface is nearly level, excepting the gentle slopes near some of the foothills, and its drainage is generally poor. When once the deep clay areas become saturated with water and the subsoil water nears the surface, it is a difficult matter to remove it, owing to the close texture of the soil. This soil owes its origin both to the disintegration of the Fort Benton shale in place and to the transportation of the same disintegrated material. As this shale contains considerable quantities of salts, the same is generally true of the derived soils. This soil is very difficult to cultivate to grain crops, drying into a hard crust after a rain. When not too alkaline it is generally well adapted to timothy, blue-joint, red-top, June grass, and other grasses.

The Billings loam covers 14,144 acres, or 20.7 per cent of the area. It owes its origin to a mixture of the disintegration products of the Fort Benton shale and the sandstone on the north side of the valley,

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and thus the texture ranges between sandy loam and clay. It cultivates quite easily, giving a much more pulverant surface than the Billings clay, and does not form so hard a surface upon drying. The underground drainage of this type is generally better than that of the Billings clay. The Billings loam contains some alkali, though not as much as the Billings clay. It is adapted to grain and vegetables, but is better adapted to alfalfa and grasses. Fruit trees are doing fairly well on some areas of this type.

The Billings sandy loam, the third soil in order of extent, covers 13,568 acres, or 19.8 per cent of the area. This soil occupies the gentle slopes of the foothills of the sandstone bluff and is seldom found on the lower levels. It is derived from the transported material of the disintegrated sandstone on the north side of the valley. The underdrainage of this type is good, and injurious amounts of alkali are not present except in one small area. This soil is well adapted to any crop suited to the climate of the valley.

The Billings gravelly loam, covering 11,776 acres, or 17.2 per cent of the area, is of the same composition as Billings sandy loam, except that it contains much gravel. It is generally found on or near the terraces, which were former river banks, most of the soil having been removed from these places by transportation, leaving the gravel outcrops. It is free from alkali and well drained. Near the edge of the terraces it is of little or no agricultural value, being too gravelly, but farther back on the plateau it is well adapted to grain, vegetables, and alfalfa.

The Laurel sandy loam, the last in order of extent, covers 8,832 acres, or 12.9 per cent of the area. This is an alluvial sandy loam soil, which owes its origin to the Yellowstone River, being composed of deposits of material carried by that stream when it flowed in other channels than the present one. Its surface is usually level, but it is intersected in many places by sloughs and old river channels, and there are many swampy areas, due to seepage from irrigating ditches. The general drainage of the type is not good. This soil is the only one in the area found to contain black alkali, the presence of which is due to the seepage waters which flow from the higher-lying lands. When unaffected by alkali this soil is excellent for grain, vegetables, alfalfa, clover, and fruit.

In addition to the five soil types above described, there are in the area 3,008 acres of swamp, constituting 4.4 per cent of the total. This exists in the form of small tule swamps or marshes, caused by seepage water, due to excessive irrigation. They are of no present agricultural value, being generally too wet even for pasturage.

There is an abundance of irrigating water in the area surveyed—more than the present canal system can use, and more than is necessary to completely irrigate the whole valley. The supply comes from the

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Yellowstone River, which furnishes a good quality of water. This river is much more constant in its flow during the summer months than is usually the case with the intermountain streams, owing to the fact that Yellowstone Lake, the source of the river, is constantly fed by springs and the melting of the snow in the mountains surrounding it. There are a number of canals or ditches in the area surveyed which furnish irrigation for about 40,000 acres of land.

The underground and seepage waters of the area contain considerable amounts of salts in solution. This condition of the subsoil and drainage waters indicates forcibly both insufficient underground drainage and the existence of accumulations of salt in the subsoil.

All of the soils of this area contain more or less alkali. In general, the most alkali is found in the areas classified as Billings clay and Billings loam. Alkali is not, however, found in all of the clay areas, as some of these have a light subsoil, giving good underground drainage.

The vertical distribution of the alkali varies much, this being determined by the texture of the soil and subsoil and by the position of the underground water. The source of most of the alkali found in the soils is in the shales underlying the sandstone beds on the north side of the valley. A noticeable feature in the composition of the alkali of this area is the remarkably small amount of normal carbonates or black alkali. A comparison of alkali conditions as found to exist at the time of this survey (1902) with those existing in 1898, when a party from the Bureau of Soils made a study of the alkali soils around Billings, indicates that the conditions are much worse now than four years ago, both as regards salt on the surface and in the subsoil.

As a rule, very little attention is paid to rotation of crops, owing to the overshadowing importance of hay production. Alfalfa is the main crop of the region. Grain is sometimes raised in rotation with vegetables, and is the crop usually sown when an alfalfa field is plowed up. Alfalfa is usually grown on the lighter soils with sandy subsoil, while timothy and blue-joint grass are usually sown on the heavier soils. On the alkaline soils of the area a number of grasses, among them fox-tail grass, sweet clover, and salt grasses, are grown for pasturage. Vegetables and fruit do well on some of the soils, so far as attempts at their cultivation have been made. It is proposed to start a drainage experiment in this area to demonstrate to the people that the alkali problem, which has caused much damage and apprehension, can be easily and profitably controlled.

LEWISTON AREA, IDAHO.

The Lewiston area covers about 308 square miles, or 197,248 acres. It is 12 miles wide and 24 miles long, extending from Lewiston, the county seat of Nez Perces County, northward to Moscow, the county seat of Latah County. It embraces a typical section of the famous

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Palouse wheat country and, in the vicinity of Lewiston, an important irrigated orchard district. Physiographically the area consists of two plateaus intersected by the valley of the Clearwater River. The Uniontown Plateau, lying south of Moscow, is a rolling plateau about 3,000 feet high, out of which protudes an irregular ridge several hundred feet higher. South of the river the Lewiston Plateau, of which but a small part was included in the present survey, has an elevation of about 1,500 feet and a surface less rolling than the Uniontown Plateau. The valley has an average width of 1 mile, and is flanked on its northern side by bluffs rising to a height of 2,000 feet. The valley consists of small sedimentary terraces, the most conspicuous of which is occupied by the town of Lewiston and lies about 100 feet above the river. Similar terraces are also found along the larger tributaries of the Clearwater River. The differences in elevation between the ridges and the valleys of the upland range from 50 to 150 feet.

The rocks are of two sharply defined groups, one a Pre-Tertiary group of granites, schists, and light-colored igneous rocks. The area occupied by these is limited to an island-like ridge or "steptoe" extending from a point east of Moscow in a south and southwest direction. These rocks break down into a light-colored soil of average fertility. The other group consists of Columbia River lava, together with sedimentary deposits of lapilli and volcanic dust, which occur between the lava sheets. This series, which is of Tertiary origin, lies unconformably over the older group, except where the steptoe is protruded. The basalt weathers into a deep, dark, uniformly textured soil of remarkable fertility.

Since the return of high prices for wheat and other cereals following the general depression of 1893 and 1894, the condition of the agricultural classes in the section of the country of which the Lewiston area is a part has been one of increasing prosperity. The people as a whole are energetic, and the methods of farming are becoming more careful as the larger ranches give way to smaller farms. The wheat lands are now allowed to lie fallow every third or fourth year, or in some cases every other year. This method is of comparatively recent introduction and is said to amply repay the trouble and expense. The farms range from a few acres in the valley near Lewiston to 1,000 or more acres in the upland wheat farms. Land values vary widely. The best wheat lands in the Uniontown Plateau are held at from $15 to $60 per acre, the average being not far from $35. Land along the Clearwater River and under irrigation will bring $150 an acre, and when in orchard much more.

On the greater number of farms, excepting, of course, the very large wheat farms, the labor is performed by the owner and his family, save possibly during harvest time. Wages of farm labor range from $15 to

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$25 per month, with board in addition. During harvest day wages go up to $2 or $3 per day, with board, depending upon the character of the work. The growing of wheat is the chief industry, but the other grains, except corn, are important, as is also flax. Stock raising and dairying are increasing, and as the soils of the plateau are well adapted to many different grasses and forage crops these lines of agricultural industry should be greatly extended in the future. In the valley of the Clearwater the growing of fruit and truck crops are the chief interests at present and in prospect. Transportation facilities are fairly good. Moscow, Genesee, and Lewiston are all shipping points. The area supplies a considerable proportion of the 50,000,000 bushels of wheat annually sent out of the famed Palouse district.

The Yakima fine sandy loam, covering 172,992 acres, or 87.7 per cent of the area, occurs on both the Uniontown and Lewiston plateaus. The surface generally consists of rolling hills and intervening valleys. The soil is derived from deeply weathered trappean rocks, principally basalt. Not uncommonly the soil mantle reaches a thickness of 30 feet, though the depth varies much and on steep slopes the soil is sometimes quite thin. A little alkali is found in the draws, but the drainage of the type is good, and even if irrigated there would be little danger of an accumulation of these salts in injurious quantities. Wheat is the staple crop. The average yield is about 30 bushels per acre. Sometimes as many as 70 or 80 bushels of oats or barley are obtained per acre, and the average yield is above 40 bushels. Flax is not as extensively grown as the cereals, but it does well, the yield per acre ranging from 15 to 20 bushels. The season on the plateau is too short for corn or sugar beets, frosts occurring as early as September 1. Small orchards of apples and cherries are found on this type, and these fruits, berries, and other small fruits do well.

The Yakima silt loam, covering 15,936 acres, or 8.1 per cent of the area, occupies many of the local valleys, depressions, and necks between the hills of the plateau. The surface is generally quite level and drainage is often deficient. The type has been derived from wash from the soils of surrounding higher areas. Wheat is the chief crop, and the yield is better than on the Yakima fine sandy loam. Timothy is also important, and does better on this than on any other soil in the area. Barley and oats give yields above the average. Hungarian brome grass and alfalfa also grow well, and the former is being substituted for timothy on account of its hardy, drought-resisting nature and heavier yield. Although this soil gives large yields of the grains, it is probably best adapted to the grasses and for pasturage. It is not adapted to orchard fruits, nor to cultivated crops requiring a long growing season, as it is slow to warm up in the spring and first to be affected by frosts in the fall.

The Yakima sandy loam, covering 6,208 acres, or 3.1 per cent of the

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area, is a friable soil of moderate fertility, derived from the crystalline rocks composing the older or Pre-Tertiary group, and forming the area of the steptoe on the Uniontown Plateau. The elevation of this soil ranges through several hundred feet up to 500 feet above the surrounding soils of the basaltic plateau. The surface is comparatively rough, and on this account most of the land has little agricultural value. Some of the more favorably located areas have been cleared of the native pine forests and planted to wheat, oats, and flax, with fair results. Wheat yields about 25 bushels and flax about 12 bushels per acre. Several small orchards of apples, prunes, and plums have been set out, but only the apples seem to give promise of profitable returns.

The Yakima fine sand, covering 2,112 acres, or 1.1 per cent of the area, is found in the Clearwater Valley, occupying small, low, level terraces. It is well sheltered by the cliffs towering to a height of 2,000 feet on the north, and is used principally for fruit growing. The growing season begins early and is of long duration, and the liability of damage from frost is reduced to a minimum. This land, with a good water supply, is held as high as the best similar lands in southern California. Nearly all the deciduous fruits are successfully grown. Peaches, cherries, plums, and table grapes are profitably grown. The soil is well adapted, also, to berries and truck crops, including watermelons and cantaloupes.

WALLA WALLA AREA, WASHINGTON.

The area surveyed occupies the south central part of Wallawalla County, Wash., and is 8½ miles north and south by 24 miles east and west. The area contains the city of Walla Walla and includes all the lands under cultivation devoted to the growing of fruit or vegetables in that vicinity and a representative part of the wheat lands of Wallawalla County. The eastern end of the area includes a part of the compact foothill lands west of Blue Mountains, while in the western end occur the fine sandy hill lands which border the Columbia River.

What is usually known as the Walla Walla Valley is one great expanse of rolling hills. In no place is there any considerable area of level land except immediately along the small streams, which in some instances have cut out level valleys a mile or so in width. Immediately south of Walla Walla and also to the northeast of the city the hills are gently rolling, affording fields that are easily cultivated, but the foothill land in the eastern part of the area and the country in the western and northern parts is composed of very high, steep hills, which in many places are very difficult to cultivate. The small valleys are sufficiently level to readily allow irrigation. The region is well drained and has a number of streams, of which Walla Walla River and Mill Creek are the principal ones, that contain water the year around, not all of which is at present utilized in irrigation. The whole area

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and the regions beyond give evidence of succeeding periods of volcanic activity. Granite bowlders often weighing a ton are found scattered erratically over the area, and as the nearest granite mountains are miles away these bowlders must have been brought into the area by icebergs when the country was covered with water.

The Yakima sandy loam, which occupies 64,896 acres, or 50.55 per cent of the area, is a friable sandy loam of easy cultivation and good moisture-retaining qualities. It occupies all of the hill area and the most of the area in the small valleys around Walla Walla, and reaches north and south to the limits of the survey. It represents a zone extending at a distance around the base of the Blue Mountains. The greater part of this type occurs as steep, rolling hills. In the immediate neighborhood of Walla Walla these hills are only slightly rolling and not difficult to cultivate. In many places the narrow valleys along the streams are of this same soil. The greater part of this type is well drained, though a few areas of very limited extent along the streams would be benefited by drainage. As originally deposited in the lake bottom this soil came principally as the product of erosion from the surrounding high, mountainous region, with which was mixed a considerable quantity of volcanic ash. Nearly all of this soil contains a small quantity of alkali, though in most places not enough to affect crops. Nearly all the Yakima sandy loam is sown to wheat or barley. Wheat yields an average of about 30 bushels per acre and barley about 40 bushels per acre. Alfalfa is grown in places along the streams and yields well.

The Yakima fine sandy loam covers 26,688 acres, or 20.79 per cent of the area, and is a fine to very fine sand, having the properties of a sandy loam. It is found wholly in the western part of the area, and extends across the hills and valleys. The hill land is well drained, but a part of the area along the Walla Walla River needs drainage. This soil is derived from sediments of the ancient John Day Lake, with admixtures of volcanic ash. The hill lands all contain a small percentage of alkali, but there is not enough seepage to concentrate this in harmful quantities. Along the river, however, the greater part of the Yakima fine sandy loam is alkaline, and is at present used only as pasture. Nearly all the hill lands are now sown to wheat, and yield on an average about 20 bushels per acre. Barley usually produces about 30 bushels per acre.

The Walla Walla loam, which covers 23,360 acres, or 18.19 per cent of the area, is found occupying the higher hill region in the eastern part of the area. The steep slopes afford good drainage, so that even in the rainy seasons the soils are well drained. This soil was formed in the same way as the Yakima sandy loam. No part of it contains harmful amounts of alkali salts, due to the greater rainfall and absence of low, level stretches where the alkali might accumulate. The soil is

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sown almost exclusively to grain, and averages about 35 bushels of wheat and 50 bushels of barley to the acre.

The Yakima gravelly loam covers 10,048 acres, or 7.83 per cent of the area. It is found only in the level valley portions of the area and skirting the streams. The surface is comparatively level and the soil is well drained. This soil is the direct result of the erosive action of the streams along which it occurs. None of it contains harmful amounts of alkali. Only about 30 per cent of the soil is cultivated. It is planted to vegetables and small fruits that require irrigation. The remainder of the soil, usually along the streams, is used for pasture land.

The Yakima loam occupies 3,392 acres, or 2.64 per cent of the area. This is a deep, friable loam, and is found only along the small streams of the area, where it exists in small, level areas. It is usually fairly well drained. It has been formed from the finer sediments of the streams mixed with organic matter from decaying vegetation. Very little of the soil is alkaline. It is nearly all planted to vegetables, small fruits, and alfalfa, producing fair crops of all.

Irrigation in the vicinity of Walla Walla is confined to the small valleys, as the hills are too rough to permit of any practicable method of applying water. Even of the valley land but a very small percentage of that nearest Walla Walla is irrigated. This is planted principally to truck and fruits. The water for this irrigation is taken from the creeks in very small ditches, which are owned by the irrigators individually. With a careful distribution of the water the irrigated area along the creeks could be increased about one-half. In all there are about 5,000 acres of land within the area mapped that could be economically irrigated.

Toward the western part of the area, along the Walla Walla River and Mud and Dry creeks, the land is alkaline, some of it so much so as to be practically abandoned. Even in the small valleys about Walla Walla and in some places on hillsides small patches of alkali are seen, but these patches are limited in extent and the percentage of alkali present in the soil is very low. The alkali in this area is nearly all carbonate and bicarbonate of sodium, or "black alkali," the most harmful salt found in the soil. There is no alkali land in the area mapped that can not be economically reclaimed. It is all situated in the small valleys along the streams, and the soils are of such an open and porous nature that alkali may be readily washed from them. The numerous small streams that intersect the area are usually far enough below the level of the valleys to afford good outlets for drains.

No rotation of crops is practiced in the Walla Walla area, wheat and barley being grown continuously and almost exclusively. The only other crops are vegetables, fruit, and alfalfa grown along the streams. Wheat has by far the larger acreage, only enough barley being grown

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to meet the home demand. No crop has yet been introduced to rotate with the wheat, so that the common practice is to "rest" the land by fallowing it one year in three, or, in the majority of cases, every other year. The fruits grown in this area consist principally of prunes, apples, pears, cherries, and a few other deciduous fruits. Experience has shown that these fruits may be grown back in the hill lands without irrigation, but very few orchards are as yet planted outside the level irrigated lands of the valleys. All kinds of truck are grown. Potatoes, onions, cabbages, and asparagus are the principal products. In the western part of the area dairying has gained quite a foothold.

LOWER ARKANSAS VALLEY AREA, COLORADO.

This area, comprising about 945 square miles, or 604,928 acres, is agriculturally one of the most important districts of Colorado. The area reaches from a point 6 miles west of Rockyford eastward to the Kansas State line, a distance of 100 miles, and has a width of from 6 to 20 miles. It takes in all the valley lands and all the uplands to the limits of irrigation. The Arkansas River, rising in the Rocky Mountains, flows in a generally eastern direction through the area, and is the main source of water for irrigation. The soils of this area are famed for their fertility. Stock feeding and the production of alfalfa, sugar beets, melons, fruits, honey, vegetables, and other staple articles of food make up the agricultural industry.

In the more intensively farmed western part of the area, and in those parts not restricted by inadequate water supply, agriculture is flourishing. In the middle and eastern parts of the area, where the land is held in larger tracts and farmed extensively, and where there has been a recent unusual shortage of water for irrigation, the conditions are very much less satisfactory, and many abandoned farms are seen. Conditions will improve materially with the extension of irrigation systems.

Good alfalfa, grain, and beet lands, with water rights, can be bought for from $30 to $60 an acre, but adjacent to towns and shipping points values rise to from $100 to $200 an acre. There are many large alfalfa and stock ranches in the area. Excluding these, the average size of farms is about 160 acres. The American Sugar Beet Company, in selling lands to settlers, limits the amount of land to be held by one person to 40 acres. Farm labor is fairly plentiful at wages from one-fourth to one-third more than those paid in the Middle Western States. Sugar beets have become a mainstay in the agriculture of the area. A factory with a capacity of 1,000 tons of beets daily is located at Rockyford.

There are two distinct physiographic divisions in the area—the upland, consisting of a succession of smooth, even, gently undulating

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prairies, and the valley, from 2 to 5 miles wide, carved out of the upland, or Great Plains, to a depth of from 100 to 300 feet, by the Arkansas River. The basal rocks consist of alternating beds of sandstone, limestone, and shales of marine origin and Cretaceous age.

Including Dunesand and Riverwash and Swamp, 12 soils were found in the area. The most extensive, the Fresno fine sandy loam, covers 236,288 acres, or 39.1 per cent of the area. This is a deep, fine, close-textured soil derived from limestone, occupying higher valley terraces and the uplands. In the former situation it is nearly all under cultivation, but in the uplands large areas of it are yet without water, although irrigation is practicable and will be had in the future through the extension of the storage reservoir systems now being developed. A large proportion of the unirrigated land is devoted to grazing. With irrigation large crops of alfalfa, wheat, corn, potatoes, fruits, sorghum, melons, sugar beets, etc., are produced.

The Maricopa sandy loam, covering 156,096 acres, or 25.8 per cent of the area, is a coarse sandy loam, but with a heavy subsoil and a marked capacity for holding moisture. It occurs on the uplands on both sides of the valley and on the valley floor. In origin it is sedimentary, being composed on the uplands of deposits from ancient streams debouching on the plain from the mountains, and in the valley of deposits of the Arkansas River. On the uplands south of the river the soil is used chiefly for grazing. Much of the type lies too high for irrigation with present canal systems. However, a good deal of it in lower situations is cultivated. Fruit and melon culture are becoming important industries on this soil, while the other staples of the region give excellent results.

The Fresno sand, covering 95,680 acres, or 15.8 per cent of the area, is the soil forming the greater part of the upland sand areas of the Great Plains of southeastern Colorado, and owes its origin to the interlacing drainage deposits of the formative period of the plains. It is a coarse, open-textured soil, and while holding moisture comparatively well is not so good for agricultural purposes as the heavier soils. Not much of this soil on the uplands is cultivated. With the addition of stable manure or organic matter in some other form, and a generous application of water, good yields of the staple crops are produced.

The Santiago silt loam, covering 37,760 acres, or 6.2 per cent of the area, is found only in the valley bottoms, lower stream terraces, or local depressions. It is a stiff, adobelike soil and is difficult to cultivate. Some areas are overflowed at high water. Alkali occurs to some extent. Most of the areas are used for pasture, but there are valuable farms and ranches located on this soil throughout the area. When properly handled it is as good as any soil in the area for the production of sugar beets.

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The Maricopa sandy adobe, covering 37,248 acres, or 6.2 per cent of the area, is one of the most important upland soils. It generally occupies the lower levels or draws of the plains. Under natural conditions the drainage is generally good, but some tracts have been damaged by seepage water and need tiling. The type contains considerable alkali, but this at present is largely confined to the subsoil, except in small areas, and does not seriously affect the crops. It is a source of danger, however, and precaution should be used in cultivation and irrigation to prevent surface accumulation. Owing to its position a considerable part of this soil is unirrigated and uncultivated. Such areas are used for grazing. The raising of alfalfa for seed and hay is the leading interest, although other crops, especially the grains, do well.

The Maricopa sand, covering 14,208 acres, or 2.3 per cent of the area, differs from the Fresno sand in having a subsoil of heavier material at about 3 feet below the surface. This soil occupies higher slopes and levels of the plains. Its origin is that of the Fresno sand, though it has been modified to a greater extent by wind action. The type is free from injurious amounts of alkali. The greater part of the area lies above irrigation, and is useful only for grazing. It is best adapted to tomatoes, melons, and other truck crops. With the addition of stable and green manures this soil should produce fair crops of alfalfa, grain, sorghum, and sugar beets.

Riverwash, which is of no agricultural value, occupies 12,800 acres, or 2.1 per cent of the whole area.

Fresno fine sand, covering 5,952 acres, or 1 per cent of the area, occurs on the lower terraces along the Arkansas River and its tributaries. The type is normally free from alkali, but has been contaminated in places by seepage waters. The areas are but slightly raised above the river and are subject to overflow, and are generally of little value except for grazing.

The San Joaquin black adobe, covering 4,096 acres, or 0.7 per cent of the area, is one of the least important soils. It occupies depressions and old slough bottoms and is generally poorly drained. It is affected by alkali and very little of it is under cultivation. Where thoroughly drained it is best adapted to sugar beets and alfalfa.

The Dunesand, covering 3,328 acres, or 0.6 per cent of the area, is of no agricultural value.

The Maricopa clay loam covers 832 acres, or 0.2 per cent of the area. It occupies depressions and much of it is affected by seepage waters. If drained and reclaimed from alkali conditions, it could be made to produce good crops of alfalfa, sorghum, corn, and other crops adapted to soils of heavy texture.

The Swamp areas occupy 640 acres, or about 0.1 per cent of the area surveyed.

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YUMA AREA, ARIZONA.

This survey covers 63,469 acres, or about 100 square miles, in the extreme southwestern corner of Arizona, extending as a narrow strip along the Colorado River. The area is bounded on the east and south by a bluff or river terrace from 40 to 75 feet high that separates the bottom lands from a high, level mesa. This mesa is cut by the river at Yuma and comes within a mile of the river just south of the limits of the survey. Across the river to the north is the State of California, and west of the river, where it flows nearly south, is Lower California, a Territory of the Republic of Mexico.

The area forms a part of the Colorado River Delta. The entire valley is made up of sediments, and consists of a great bed of sand overlain and interstratified with layers of finer material left by the river as it has shifted its course from one side of the valley to the other. Brought together from widely separated regions by the many tributaries of the Colorado, the materials forming the sediments are numerous and varied. Three-fourths of the valley lands are overflowed annually. The surface as a whole is a plain, gently sloping toward the southwest. This is broken by local areas of sand dunes, and by gullies, lagoons, and old river channels. In some cases, as where sand dunes occur, the preparation of the land for irrigation is too expensive to be profitable under present conditions, but the greater part of the land requires very little leveling.

Agriculture is in its infancy. The majority of the farmers live in brush and log houses plastered with mud and having dirt roofs. The chief products so far are alfalfa and live stock. Barley, sorghum, and kindred field crops are also produced to a limited extent. The region is very arid, the normal annual precipitation being only about 3 inches, falling mainly in the fall and winter months. All agriculture must depend upon irrigation. The first ditch was built shortly after 1891. The water was pumped from the river and proved very expensive. In 1895 irrigation by water pumped from artesian wells was attempted, but the water-bearing sands were too fine to permit the water to flow freely enough to keep the pumps supplied, and the plan failed. Several large canals to supply the overflow lands by gravity have since been constructed, but the river water is so muddy that the canals fill very rapidly with silt, and up to 1902 very little land had actually been irrigated. Dredges were in course of construction when the survey was being made, and it is hoped by means of these to keep the canals clear. This problem is the most difficult one confronting the citizens of the Yuma area.

There is considerable alkali in the soils of the area, particularly in those of heavy texture, lying above the floods. Much of this, however, is found in soils of sandy or fine sandy texture, and if proper drainage is maintained it can be removed by a few heavy irrigations.

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The Imperial loam, covering 20,800 acres, or 32.8 per cent of the area, is the most extensive soil in the survey. The greater part of the area of this soil is overflowed annually and can not be cultivated with any certainty of success. If protected from the floods it could all be brought under cultivation with but little preliminary leveling. Small areas lying above high water produce alfalfa, sorghum, and other field crops. Alfalfa can not be pastured, however, as the soil packs and the plants die out. The soil is well adapted to corn, wheat, and alfalfa. A great part of the area of this soil lying above high-water mark contains an excess of alkali, and where the soil is 5 feet or more in depth great care must be taken to prevent further accumulation of the injurious salts. The texture and position of this soil make it a type very susceptible to damage from alkali.

The Gila fine sandy loam, covering 17,038 acres, or 26.8 per cent of the area, occurs in long, narrow, level strips skirting the present and former river courses. The soil is a fine sand having the properties of a sandy loam. It is easily cultivated, remains in good tilth a long time, and should prove one of the most productive soils of the area. Very little of the soil is under cultivation. Crops of any kind suited to the climate do exceptionally well. Alfalfa is the crop most largely grown at present. Owing to great capillary power and nearness of the water table great care will be necessary to prevent the accumulation of alkali.

The Imperial sandy loam, covering 12,806 acres, or 20.2 per cent of the area, is a loose, friable soil requiring little cultivation to maintain it in good tilth. It is level and easily prepared for irrigation. The areas lie for the most part above high-water mark. It has a high capillary power, and careful methods of cultivation and irrigation will be found necessary to prevent the accumulation of alkali, although with ordinary care there need be little fear of damage from this cause. Alfalfa, sorghum, barley, and kindred field crops are the only products yet grown on areas of this soil.

The Imperial sand, covering 9,062 acres, or 14.3 per cent of the total area, is found skirting the mesa and in isolated areas throughout that part of the valley not subject to overflow. Excepting the sand-dune areas, the surface is comparatively level. Along the mesa the soil has been formed by the wearing down of the mesa; in other places it is river sand that has not been covered by finer sediments. The soil is loose and incoherent. Large areas have been drifted by the wind into dunes ranging from 5 to 20 feet in height. At present the leveling of such lands will not pay. The soil is well drained and free from alkali. Alfalfa is the only crop so far grown commercially. The soil is well adapted to certain of the truck crops.

The Santiago silt loam, covering 3,763 acres, or 5.9 per cent of the area, in texture is intermediate between the Gila fine sandy loam and

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the Imperial loam. It is a very fertile soil, has a level surface, and only in limited areas contains injurious amounts of alkali, although nearly all of it contains at least a small quantity. None of this soil is now under cultivation. Similar soils in California are used successfully in the production of celery and lima beans. It is also well adapted to all the common field crops.

It is believed that the soils of the Yuma area may be profitably utilized to produce dates, which are resistant to alkaline conditions of the soil. The adaptation of crops, however, has yet to be worked out. The possibilities of diversification are great, but the growing of some special crop or crops that can not be produced in more northern and colder parts of the United States seems to offer the best opportunity for the establishing of a permanent and profitable agricultural industry in the area.

ARECIBO TO PONCE AREA, PORTO RICO.

The area surveyed in Porto Rico comprises a strip of country about 10 miles wide, extending across the island from Arecibo on the north coast to Ponce on the south. The area contains 211,180 acres, or about 330 square miles. No accurate base map was procurable, and the soil survey was preceded by a traverse party, who determined the boundaries of the area and the location of the principal towns, roads, trails, and streams. The military road connecting Ponce and Arecibo runs through the middle of the area.

Passing over the island from one side to the other, the area cuts the several geological formations, and it is believed the soils classified comprise nearly all, if not all, the types to be found in Porto Rico. There are three main physiographic divisions in the area—the central mountainous region, composed of igneous and volcanic rocks; surrounding this is a greatly eroded region, once a plateau, sloping toward the sea and consisting of coral limestone; and, lower down, the coastal plains, with their low, rounded limestone hills, swamps and lagoons, and rich alluvial lands at the river mouths. The altitude ranges from sea level to 3,400 feet above, on the peak of Mount Guilarte. The crest of the divide is about 15 miles from the south coast and 25 miles from Arecibo. The descent to the south is much more rapid than to the north. The interior mountain region and the surrounding limestone belt are very rough and rugged. The latter region shows the effects of erosion on a tremendous scale, being cut by steep-sided canyons and pitted with sink holes having perpendicular walls rising 100 and sometimes 200 feet. The area is well drained by the Arecibo and Tanama on the north of the divide and by the Portugues, Tallaboa, and other small streams on the south. There is little variation in the temperature from month to month. December, January, and February are considered the coolest months, while

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August, September, and October are the warmest. The difference is probably more a sensible than an actual one, due to relative humidity and the character of the trade winds. The annual rainfall at Adjuntas, in the interior of the island, is nearly 100 inches. South of the divide the rainfall is very much less and is so distributed that irrigation is necessary for the successful cultivation of most crops.

The agriculture of Porto Rico and of the area surveyed is now recovering from a period of depression caused by the destructive hurricane of 1899, the Spanish war, and the ruling low price of sugar. The area is thickly populated, having more inhabitants to the square mile than any of the States except Massachusetts and Rhode Island. About three-fifths of the inhabitants are white, the remainder being negroes or persons of mixed blood. About 97 per cent of the farms are owned, the remainder being rented. When rented on shares to the peasant class, one-half the crop is reserved by the landlord. Eighty-nine per cent of the land in farms is owned by whites. The average size of farm is about 50 acres, of which an average of about 35 per cent is cultivated. The labor is performed by peons at a wage of 40 cents, or, in the sugar districts, occasionally 50 cents a day. The labor is intelligent, apt, and willing to learn, though illiterate, 83 per cent of the entire population being unable to read. The women and children assist in some of the lighter farm work, but do not labor generally in the field, as in some of the other tropical islands. There is great poverty among the laboring class.

The agricultural development of Porto Rico has been based mainly on the production of sugar and coffee, both of which have been grown for centuries. The exportation of sugar reached its maximum in 1870, when 100,000 tons were shipped out of the island. In 1899 the shipments amounted to only 70,000 tons. The production of coffee reached its maximum in 1897, but the severe hurricane of September, 1899, destroyed many plantations and left the industry in a shattered condition. Between 5 and 15 per cent of the cultivated lands of the area are in sugar cane, and from 40 to 50 per cent in coffee. The coffee is of superior quality and finds its way into European markets. A fair quality of tobacco is grown in the area. It formerly went largely to Cuba and was classed with the Habana. The methods of cultivation and curing should be improved.

These are the chief industries, and with rejuvenation and extension are sufficient to support the agricultural classes of the area. In addition the introduction of commercial fruit growing will add greatly to the resources. There is great need, as a preliminary to further agricultural development, for improved means of transportation. Excepting the military highway the roads and trails are for a good part of the year barely passable. The railways are insufficient and are confined to the coasts. United States capitalists will find opportunity for

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investment in railways, sugar mills, tobacco enterprises, coffee plantations, and in orchards of citrus and other tropical and subtropical fruits, including, as of first importance, pineapples and cocoanuts.

The adaptation of soils to crops has been adjusted empirically through the long years of culture of the various native products, but there is much room for the introduction of modern scientific methods of soil management.

Eighteen distinct soil types were recognized in the area. The type of greatest extent is the Tanama stony loam, covering 41,680 acres, or about 20 per cent of the area. This soil occurs in two large areas on both sides of the Arecibo River, in the northern part of the island, covering the major portion of the greatly eroded limestone belt. The soil is a shallow red clay, containing anywhere from 30 to 60 per cent of limestone fragments, resting on broken limestone or limestone in place. The soil is deeper in some locations. The soil is derived from a chalky white limestone and is undoubtedly fertile, but the rough and broken character of the country is against any great agricultural development upon it. Over the greater part of the area bananas and plantains are the principal crops. Coffee is cultivated, but the greater part of the area is too rough and stony for this crop. The best coffee is grown in the southern part of the area, but is not as good as that grown on some other soils. Yantia, sweet potatoes, gondules, melanga, and other minor products are grown to some extent. Tobacco is also produced on some of the areas where the soil is deepest.

The Adjuntas clay, covering 29,890 acres, or 14 per cent of the area, occupies one large area around Adjuntas. The topography is rough and broken, and great care has to be taken to prevent washing. The soil is a deep, fertile clay, derived from the weathering of igneous and volcanic rocks, and ranks next to the alluvial sugar lands in value. It is the principal coffee soil, and where richest in organic matter a yield of 400 pounds of the dried bean per acre is obtained. A few orange trees are found along the trails, and this soil is better adapted to this fruit than any soil in the area, except the Alonso clay. With better transportation facilities the growing of citrus fruits should prove profitable on this soil type.

The Utuado sandy loam, covering 25,100 acres, or almost 12 per cent of the area, occurs in one large body around Utuado. The surface consists of furrowed and gullied hills, rising 200 feet above the intervening V-shaped valleys. In few of the soils has erosion been so severe as in this type. Drainage is so rapid and thorough that crops suffer from drought even in short periods of dry weather. The soil has little natural fertility and is soon exhausted. A few coffee plantations in favored locations appeared to be thrifty, but the soil is generally too shallow and of too coarse texture to be well adapted to this crop. Sweet potatoes, beans, corn, and other minor crops are grown,

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but not extensively. The area of this soil has been deforested, and where not cultivated is now covered with a coarse, rank grass resembling sedge. The best use for these lands would be to put them again under forest.

The Arecibo loam, covering 17,700 acres, or 8.4 per cent of the area, occurs in two large areas occupying rounded limestone hills, and in smaller scattered areas near the north coast of the island. It is a heavy, fertile soil, and is derived from limestone, fragments of which are found in varying quantities in both soil and subsoil. The topography ranges from level to rolling and rough and broken, and the agriculture varies accordingly. In flat areas the natural drainage is poor. Bananas, plantains, and coffee, together with gondules, sweet potatoes, and minor produce crops are extensively grown. A small amount of tobacco is produced. Oranges and other fruits do well on the hilly areas where the soil has sufficient depth. The type is well adapted to pasturage, and in all areas except those too rough and broken is always covered with a thick mat of rich green grass.

Pastillo loam, covering 16,040 acres, or 7.6 per cent of the area, occupies one large and three smaller areas in the south side of the island, covering rolling hills of limestone, from which rock it is derived. The soil ranges from 4 to 36 inches in depth, the greater part having the minimum depth. The soil rests directly on the limestone. The type is of little agricultural value. The greater part of it is under a stunted growth of brush. A few cleared areas are used for Guinea grass and afford some pasturage during the wet season.

Portugues stony loam, covering 15,600 acres, or 7.4 per cent of the area, occupies a single large area between the soils of the south coast limestone hills and the Adjuntas clay of the higher altitudes to the north. The surface of the greater part of the area is rough, hilly, or semimountainous, and is characterized by many steep slopes. The soil is derived from igneous and volcanic rocks. The southern part of the type is used chiefly for grazing, while in the northern part some fairly successful coffee estates are found, and considerable quantities of bananas and plantains are produced. In some of the areas of deeper soil in the southern limits of the area sugar mills have been built and cane planted, but it has been found that the rainfall is not sufficient to make the cultivation of this crop profitable, and at present stock raising has been substituted on most of these sugar plantations.

The Alonso clay, covering 13,690 acres, or 6.5 per cent of the area, is a residual soil, resulting from decomposition of igneous rocks, fragments of which are often found in soil and subsoil. This soil occurs in three areas. The largest, lying along the Limon and Arecibo rivers, is used mainly for pasturage. In the area next in extent, lying between Adjuntas and Ponce, the soil is thin and the surface rough and steep, while the rainfall is scanty. Here the soil has a low

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agricultural value. The smallest area, lying southwest of Adjuntas, is the most important agriculturally. A large part of this is planted to coffee, and the yield is high and quality good. Plantains and bananas are important crops. Oranges would do well here, as the few trees seen were exceptionally vigorous and the fruit fair sized and of good flavor. It is thought this soil might be profitably used for the production of tobacco, especially the area along the Limon and Arecibo rivers, where the texture closely resembles that of the tobacco soil around Cayey.

The Arecibo silt loam, covering 8,960 acres, or 4.2 per cent, is one of the most valuable soils of the area. It lies on both sides of the Arecibo River in a large, unbroken body, while two small areas are found on the south coast. The soil has resulted from deposition of sediment carried down by the rivers into shoal, quiet waters when the present land surface was depressed below sea level. The land is now nowhere more than 30 feet above the mean water level of the rivers, but it is not generally flooded except in great hurricanes. Some areas are swampy, and those on the south coast are salt and would need drainage and diking to make them cultivable. This soil is the most valuable type in the unirrigated area for the production of sugar, to which crop it is almost exclusively devoted. The average yield of cane is about 40 tons per acre. Tobacco is grown to a limited extent along the upper reaches of the river, where the soil is more sandy. The average yield is about 600 pounds per acre.

The Utuado loam, covering 7,880 acres, or 3.7 per cent of the area surveyed, occupies the low, rounded slopes along the Arecibo River and the rolling, mountainous land a short distance south of Utuado. It is a residual soil derived from igneous and volcanic rocks. It is largely used for pasture. In favored locations some coffee plantations in thrifty condition are found on this soil, and it could probably be advantageously used in other suitable locations for the cultivation of this crop.

The Arecibo sand, covering 7,580 acres, or 3.6 per cent of the area, is a sandy soil 3 feet or more in depth, with very little difference in texture between soil and subsoil. It is of various colors, from pure white to red and brown. It owes its origin to old beach remnants or, where near the coast, to wind-blown sand from the beaches. The large area west of Arecibo grows good Guinea grass. Many different crops are produced. The red-colored sands seem well adapted to oranges, but no attempt has been made to grow this fruit on a commercial scale. The soil is very similar to the sandy soil at Palm Beach, Fla., used so successfully in the culture of pineapples, and this industry might be profitably introduced in the areas around Arecibo.

The Ponce sandy loam, covering 6,550 acres, or 3.1 per cent of the area, is an alluvial soil occupying the level plain around Ponce, repre-

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senting the flood plain of the Tallaboa, Magueys, Portugues, and Bucana rivers. Sugar cane is the principal crop, and irrigation is necessary. The yield is not so high as for the Arecibo silt loam, but a higher sugar content about makes up for the deficiency in yield. Guinea grass, grown for forage, is the crop next in importance. Considerable quantities of bananas are produced, some plantations of 10 acres or more being found. The fruit is used by the laborers on the sugar estates. The citrus fruits would do exceptionally well on this soil.

The Penuelas adobe, covering 6,680 acres, or 3.2 per cent of the area, is a deep loam resting directly on volcanic tufa. It occupies hills and slopes around Penuelas. It is difficult to till, and because of the deficiency of rainfall is used for little except pasturage, which is fairly good during the rainy season.

The Portugues adobe, covering 4,010 acres, or 1.9 per cent of the area, is found only on the south side of the island. It is a heavy soil derived from limestone. It is used for sugar cane and ranks third in the production of this crop among the soils in the irrigated district. Formerly a greater area was devoted to cane than at present, many mills destroyed by the hurricane of 1898 being abandoned and the plantations turned into grazing lands. The soil, where level enough to allow irrigation and where the supply of water is abundant, is very well adapted to bananas, which yield as high as 700 bunches an acre in a single year.

The Arecibo sandy loam covers 2,690 acres, or 1.3 per cent of the area, and occupies two large and several small, scattered areas in the northern part of the island, occurring in valleys among the outlying limestone hills. The surface is level or gently rolling, and the soil is naturally well drained. It is believed this type has been derived from a mixture of wind-blown beach sand and the residual material washed from the limestone hills. The poorer class of small farmers cultivate most of this type, growing truck, fruit, and other minor crops. A little sugar cane and tobacco are grown, but the type is not well adapted to either.

The Coral sand covers 2,620 acres, or 1.2 per cent of the area. It is found fronting the ocean on both coasts, the larger areas occurring south of Ponce. The soil is loose, incoherent, saline, and in some places drifted into dunes. Small areas have been planted to cocoanut trees, which are quite resistant to salt. They fruit in the fifth year and live to a great age. The type is one of the best in the area for cocoanut production. A few small areas within 100 yards of the sea have been cleared by fishermen and planted to plantains, bananas, and sweet potatoes, which appear to do well.

The Ponce loam, covering 2,480 acres, or 1.2 per cent of the area, is the best sugar soil on the south side of the island, to which crop it

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has been chiefly devoted for a great many years. Small areas are used for Guinea grass. The soil is very heavy and difficult to till. The surface is generally flat, with a slight inclination toward the sea, but there are hollows marking old river courses, and these have to be artificially drained before they can be cultivated.

The Vivi sandy loam, covering 1,060 acres, or 0.5 per cent of the area, occurs in one important area around Utuado and a few smaller, scattered areas southwest of that town. The soil has been formed from the wash from the hillsides mingled with stream sediments. It has a higher agricultural value and is naturally more fertile than the Utuado sandy loam. It is used to some extent for sugar cane, but its main value is for the production of tobacco, of which a superior quality of the cigar wrapper and filler grades is produced. This soil is said to be very similar to the famous tobacco soil around Comeiro. The tobacco industry around Utuado is being developed mainly on the Vivi sandy loam.

The Riverwash covers only 170 acres, or less than 0.5 per cent of the entire area. This type occurs along the lower reaches of the Arecibo River, is subject to frequent overflow, and is but little cultivated. It is covered with a growth of coarse grass which affords some pasturage.

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SOIL SURVEY OF THE BIGFLATS AREA, NEW YORK.

By LOUIS MESMER and W. E. HEARN.

LOCATION AND BOUNDARIES OF THE AREA.

The area surveyed, which is coextensive with the Elmira topographical sheet of the U. S. Geological Survey, is located in the southern part of New York State, lying principally in the counties of Chemung

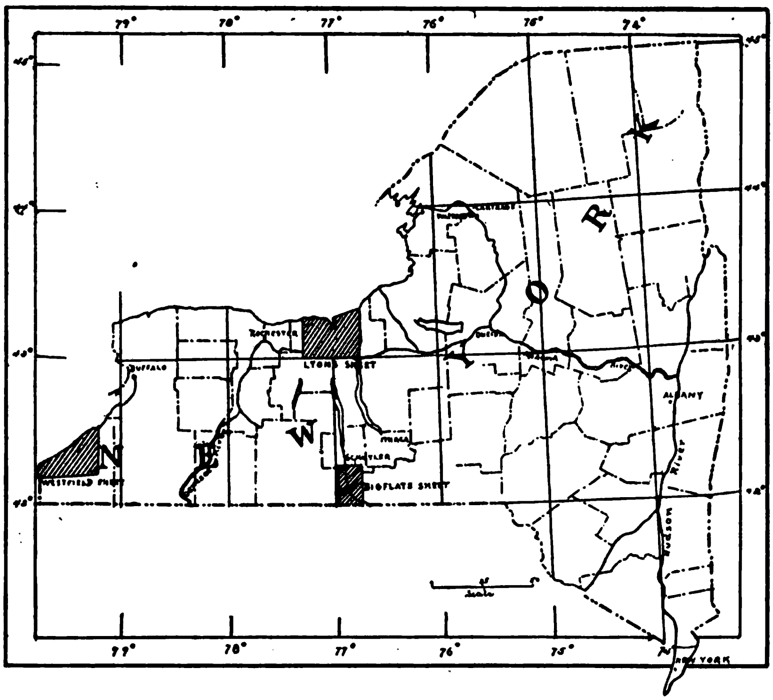

FIG. 1.—Sketch map showing areas surveyed in New York.

and Steuben and including along the southern border a small part of Bradford County, Pa. It comprises the greater part of the Bigflats tobacco district, well known for the production of a superior quality of leaf. The area contains 143,040 acres, or about 223 square miles. (See fig. 1.)

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The Seneca Indians, who occupied the Chemung Valley during the Revolutionary period, had learned some agriculture from the French,

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and when their camps were raided and destroyed by General Sullivan in 1779 there were found in the vicinity of Elmira large fields devoted to the cultivation of corn, beans, turnips, and other vegetables. Upon the destruction of their stronghold the Indians were driven back into the wilderness, leaving the valley open to settlement by the whites.

Little settlement took place, however, until 1783, when the New York State legislature passed laws very favorable to actual settlers and those holding military warrants for land. In 1788 a number of families from Orange County, N. Y., Northampton County, Pa., and Sussex County, N. J., took advantage of these opportunities and entered the Chemung Valley, building houses, clearing lands, and planting the first fields of corn.

The soils in their virgin state were fertile, 50 bushels of wheat to an acre being no uncommon yield. The development was rapid, as shown in the Chronicles, 1803, which state that from 40,000 to 50,000 bushels of wheat, besides a number of fat cattle, were being annually sent down the Susquehanna River to market. Several thousand pounds of maple sugar were made yearly. Much attention was also paid to fruit growing. Many peach and apple orchards were being set out, while some had already begun to fruit.

In 1832 the Chemung Canal was excavated. This opened a cheap way to market for all produce of the area, and, while especially favorable to the lumber interests, gave a new impetus to agriculture, which had already made marked advancement. The hills were heavily forested with oak, maple, walnut, pine, and hemlock, and as lumber was in great demand roads were opened and a large number of logs were cut and sent down the canal. As the hills were deforested the lands were gradually cleared and farmed. Thus the uplands were rapidly brought under cultivation.

The completion of the Erie Railroad in 1851, giving cheap and rapid communication with the important inland and seaboard cities, gave a second impetus to the growth of agriculture. From this time on there has been a gradual increase of the agricultural interests until at present little land remains, except the steep and impassable hillsides, that has not been turned to the plow.

To-day the area is one of the most prosperous farming sections in the State. Comfortable houses, large barns, and highly improved farms, the most striking evidence of prosperity, dot the area. The population of the valley is somewhat over 40,000.

The flourishing condition of the area is due in a great measure to diversified farming and not to any one particular crop, though wheat played an important rôle, especially in the early development. Corn, oats, rye, buckwheat, beans, potatoes, and other crops all have had a share in the building up of the region.

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Within a comparatively short time tobacco growing has come into prominence. Much improvement has been made in the methods of cultivation and harvesting of this crop, and it is now the most important product of the area, which has become the center of one of the best leaf-producing sections of the State.

Dairying and stock and poultry raising also form an important part of the husbandry, large quantities of milk, butter, and eggs, with some fat stock, being annually sent to market from this area.

CLIMATE.

The following table, compiled from records of the Weather Bureau office at Elmira, shows the normal temperature and rainfall of the Chemung Valley. There are no other stations in the area surveyed, and it is impossible to give any data that will show the climatic differences which undoubtedly exist between the valley and the hills.

Normal monthly and annual temperature and precipitation for Bigflats area.

Month.	Elmira.		Month.	Elmira.	
	Temperature.	Precipitation.		Temperature.	Precipitation.
	°F.	*Inches.*		*°F.*	*Inches.*
January	24.8	2.17	August	69.2	3.40
February	26.3	1.71	September	62.6	2.80
March	33.6	2.23	October	50.4	2.93
April	46.1	2.91	November	31.1	2.26
May	58.4	4.30	December	29.4	2.27
June	68.4	4.03	Annual	48.3	34.04
July	72.0	3.03			

PHYSIOGRAPHY AND GEOLOGY.

The topography and geology of the Bigflats area is comparatively simple. The greater part consists of rounded hills with a maximum elevation of about 1,900 feet, composed of Paleozoic shale and sandstone, with a general dip to the south. These rocks are all of the Chemung group, excepting a small body in the northern part of the area, where the Portage enters and is exposed in several places.

The Chemung Valley, which has an average width of 2 miles, enters the area about midway of its western boundary, extends in a northeastern direction to Horseheads and thence south through Elmira, leaving the area a little above the southeastern corner. This valley and its principal tributaries—the valleys along Seeley, Newtown, and Catherine creeks, the valley extending along the river west of Elmira, and the land along Fall Brook—embrace all the comparatively level and best farming land of the area. The soils here are derived from

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the wash from the hills, from glacial till and detritus, or from a combination of the two.

The sediments which formed the shale and sandstones constituting the hills and underlying the valleys in this region were laid down in comparatively shallow water either by tide or wave action, as is shown by the frequent cross-bedding of the strata. This took place in the Devonian era of Paleozoic time, when the greater portion of the American continent was under water. An elevation of the land followed, leaving a large section of country at a point much higher than it at present occupies. At this particular time the drainage of the area surveyed is supposed to have been toward the north.

A change in climatic conditions caused a great accumulation of ice in the northern part of the sphere. The ice gradually moved southward, enveloping a great part of the Temperate Zone, its southern boundary lying to the south of the State of New York. The movement of this vast ice sheet was quite uniform, but the advance and acquisition of territory along the southern border was periodical and subject to seasonal changes, being greater in the winter than in the summer. This advance of the ice was accompanied with very great erosion, large quantities of soil and rock being gouged from the surface, picked up, and carried away. From the front of the glacier water was continually given off, and the old drainage channels to the north being filled with ice, the streams were forced to find new outlets to the south.

A reversal of the climatic conditions that caused the accumulation and advance of the ice sheet forced it to retreat. As it did so, large quantities of detritus were left in its path. In the Chemung Valley, where the glacier was perhaps a thousand feet thick, the greatest accumulations are found. These occur over a generally uneven, low, rolling or terraced surface. In the vicinity of Horseheads some of these forms are well developed. To the east and north are prominent terraces, while to the west, between Horseheads and Bigflats, the low hills, undoubtedly formed of material left by the retreating ice, can be plainly seen. The melting of large quantities of ice as the retreat was in progress produced enormous volumes of water, which drained down steep inclines and eroded out deep channels. At this period a general subsidence of the continent, in what is known as the Champlain epoch, took place. This perhaps augmented the melting of the ice, but in any event the rivers, deprived of their fall, were unable to carry off all the coarse material given off by the ice and much was necessarily deposited.[a] The subsidence was in turn followed by the terrace epoch of gradual reelevation to the present point. During this period much

[a] A well in the valley near Horseheads is said to have encountered glacial till to a depth of about 90 feet.

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FIG. 1.—MIAMI GRAVELLY LOAM, BIGFLATS AREA, NEW YORK.

This is one of the most gravelly soils of the Chemung Valley, but is esteemed the best tobacco soil. As with all the soils of the valley, this requires heavy annual applications of stable manure.

FIG. 2.—PEAT SOIL, ADAPTED TO CELERY, BIGFLATS AREA, NEW YORK.

These muck areas, although smaller in extent, are esteemed among the most valuable soils, being used principally for celery, onions, and cabbages.

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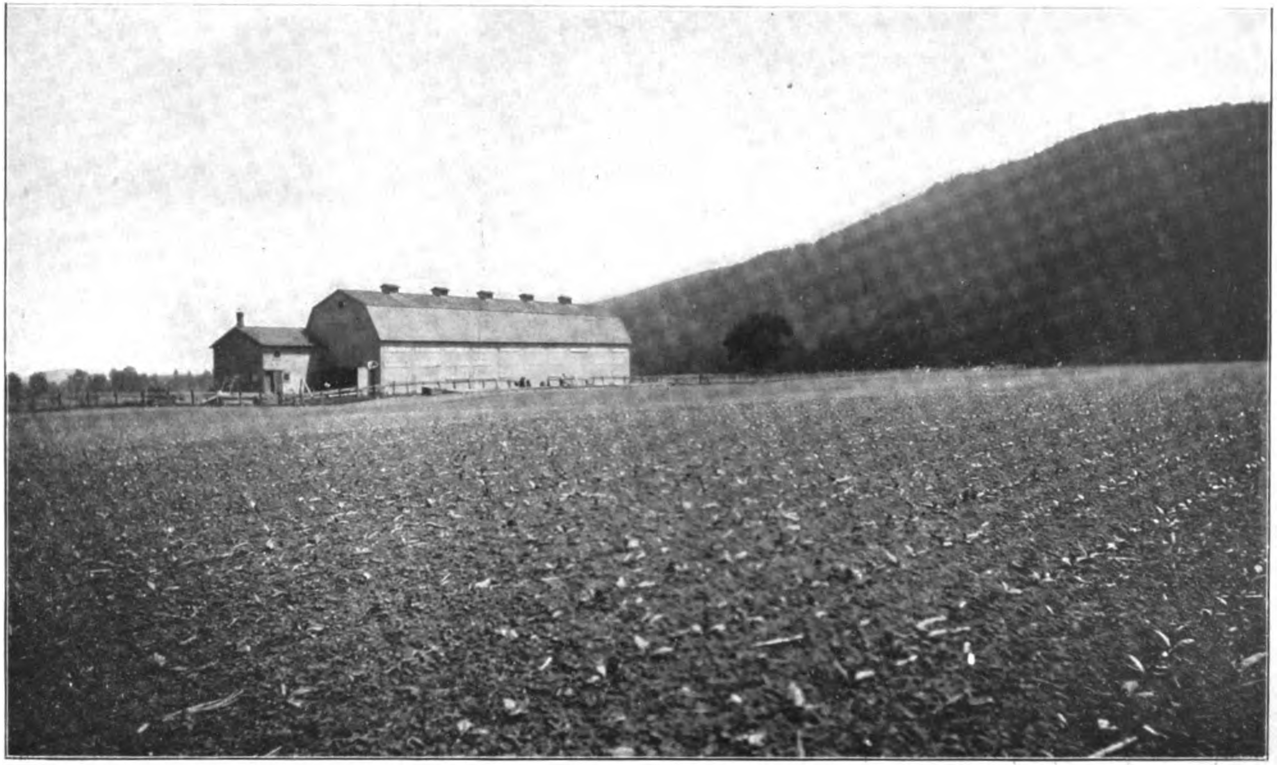

TOBACCO FIELD ON ELMIRA FINE SANDY LOAM, BIGFLATS AREA, NEW YORK.

This illustration shows the very level character of the valley lands, and the steep escarpment of the Hagerstown shale loam of the upland plateau; also the substantial character of the tobacco barns of the area.

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erosion has taken place and all the glacial drift that remains in the hills at the present time is an occasional transported bowlder. The storm waters have greatly washed the hills and in many places cut steep gullies, down which large quantities of soil are annually carried and deposited over the glacial till of the lowlands in the form of cone or fan shaped deltas. In the valley the river and large creeks are slowly cutting and forming terraces in the material which was deposited during the Champlain period.

SOILS.

There are two distinct classes of soils in the area surveyed—transported or sedimentary soils and sedentary or residual soils. The latter class is confined to the hills, which cover the greater part of the area, and is the result of the weathering and disintegrating in place of the Paleozoic rocks of the Chemung period. The former embraces glacial deposits partially modified by water, the washings from the surrounding shale hills, and the sediment resulting from the blending of glacial material with that from the shale hills carried down and deposited by the Chemung River.

The following table shows the extent of each of the seven types mapped, and the proportion which each bears to the total area:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Hagerstown shale loam	108,800	76.1	Meadow	1,920	1.3
Miami gravelly loam	15,680	11.0	Peat	576	.4
Elmira shale loam	8,512	6.0	Total	143,040	
Elmira fine sandy loam	5,632	3.9			
Elmira silt loam	1,920	1.3			

MIAMI GRAVELLY LOAM.

The Miami gravelly loam consists of a light-brown sandy loam, averaging about 16 inches in depth and containing various amounts of stone and gravel up to 60 per cent. It is a loose, friable soil, and when the stone and gravel content is not too high it is fairly easy to till. Where the stones occur in such quantities as to seriously interfere with cultivation large numbers have been picked up and hauled from the fields. The gravel is usually well rounded, having the subangular form, obtained by glacial and water action, to a greater extent than that found in any other of the soil types of the area. (See Pl. I, fig. 1.) The fragments are mostly shale, but the great quantity of transported rock—red and white sandstone, quartz, granite, etc.—is a striking characteristic of the type. The subsoil is of a yellowish color and

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contains a less amount of loam and a higher percentage of gravel. Underlying the gravel occasional sand beds are found.

A slight variation from the general type occupies some of the low rolling hills between Horseheads and Bigflats. In this location the gravel is not so plentiful, and the interstitial material varies from a sandy loam to a fine sandy loam.

The Miami gravelly loam occupies about 50 per cent of the Chemung Valley, occurring in the form of low, rolling hills, gently sloping plains, terraces, and isolated glacial dumps, or as the capping of small, rounded knolls or benches situated at the base of the main hills, though generally separated from the hills by slight depressions.

The soil has been formed to a great extent from glacial deposits or the sediments left by overflows. These in turn have been partially reworked by water and mixed to a great extent with shale fragments. Years of weathering, with a slow accumulation of humus, have resulted in the present loose, porous, well-drained soil.

Most of the ordinary farm crops, including tobacco, rye, wheat, corn, buckwheat, potatoes, and beans, are raised on this soil. Tobacco commands special attention, and where well fertilized with stable manure yields of from 1,300 to 2,000 pounds per acre are obtained, the average being probably not far from 1,500 pounds. The leaf is of a superior quality, light in color, of fine flavor, and generally considered the best produced in the area.

The following table shows the texture of typical samples of the soil and subsoil of this type:

Mechanical analyses of Miami gravelly loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.[a]	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6775	½ mile W. of Horseheads.	Light-brown sandy loam, 0 to 18 inches.	1.88	15.52	25.32	7.68	4.66	8.56	27.46	10.02
6772	¼ mile W. of Bigflats.	Gravelly loam, 0 to 20 inches.	3.36	1.08	5.16	5.24	14.32	19.96	43.56	10.18
6774	3¼ S. 3 miles E. of Elmira.	Sandy loam, 0 to 12 inches.	3.62	3.00	6.52	4.64	9.62	24.00	42.14	10.84
6773	Subsoil of 6772......	Gravelly loam, 20 to 40 inches.	1.42	1.06	6.50	6.54	13.36	21.84	36.82	13.04

[a] The "organic matter" in this and subsequent tables was determined by a wet combustion of a sample of the soil with chromic acid and multiplying the carbon dioxide obtained by the conventional factor 0.471 proposed by Wolf, Van Bemmelin, and others.

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ELMIRA FINE SANDY LOAM.

The Elmira fine sandy loam is a light-brown fine sandy loam, varying in depth from a few inches to more than 3 feet. The average of a large number of borings gives a depth of 17 inches of fine sandy loam underlain by a more sandy subsoil, lighter in color and becoming coarser in depth, or by silt. From this typical section there are slight variations, due to the action of the river, which here and there has deposited sand or silt over small areas. In the borings local differences observed were occasional streaks of sand in the fine sandy loam or silt of surface or subsoil. Considering the manner in which this soil has been laid down and the frequent overflows to which it has been subjected, these variations are of less extent than might reasonably have been expected; in fact, such areas were too few and too small to warrant classification under a separate type name.

The areas occupied by the Elmira fine sandy loam cover the major part of the bottom lands and occasional terraces, locally called "abutments," along Chemung River and Newtown Creek. (See Pl. II.) This type constitutes the alluvial lands formed by the blending of the washings from the shale hills with those from the glacial deposits. It is well drained, light, and friable, and the easiest soil to farm in the area.

Where the lands are subject to frequent overflow and are farmed to crops requiring cultivation, it is found advantageous after harvesting to put the lands in sod by sowing a hardy crop, like rye. This protects the soil from washing and checks the velocity of the flood water, which often deposits an inch or more of fertile sediment. On the other hand, where the soil is low and unprotected great quantities of earth are often removed by the flood waters, which scour out wide gullies often more than a foot in depth.

When the extent, natural fertility, and general productiveness of this soil are considered, it stands first in importance among the soils of the area, and in value per acre is only exceeded by the Peat. Large crops of corn, wheat, oats, rye, buckwheat, potatoes, clover, timothy, and tobacco are grown. A few small apple and pear orchards in the vicinity of homes were said to fruit well.

On this soil the tobacco attains its greatest height and size, but the leaf is coarser and not as light colored as that raised on the Miami gravelly loam or the Elmira shale loam, and on this account it does not command as high a price. Exceptions to this rule are the sandy variations of the type, covering very small areas, upon which the tobacco has a light color and a thin leaf. In one of these places, protected by a levee from overflow, one-half acre of Sumatra tobacco was grown beneath shade in the season of 1901 with results so satisfactory that this year about 5 acres have been tented.

The appended table shows the texture of typical samples of the soil and subsoil of this type.

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Mechanical analyses of Elmira fine sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Sil., 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6764	¾ mile SE. of Elmira.	Sandy loam, 0 to 40 inches.	1.44	0.18	0.54	1.04	19.26	43.06	28.76	7.16
6767	2 miles S. of Bigflats station.	Fine sandy loam, 0 to 20 inches.	2.51	.12	.38	.28	9.90	36.30	43.10	9.88
6765	1 mile SW. of Bigflats.	Brown sandy loam, 0 to 14 inches.	1.75	.16	.90	.74	6.02	30.44	48.26	12.60
6769	3 miles S., 2¼ E. of Elmira.	Silty loam, 0 to 30 inches.	1.53	.00	.28	.26	2.58	15.34	62.48	18.24
6768	Subsoil of 6767......	Sand, 20 to 40 inches.	.68	.04	.28	2.18	18.72	34.00	36.52	8.26
6766	Subsoil of 6765......	Fine sandy loam, 14 to 40 inches.	.31	.00	.30	.40	4.10	27.08	49.40	18.38
6770	Subsoil of 6769......	Yellow silt loam, 30 to 40 inches.	.60	.00	.10	.34	.98	10.58	67.04	20.28

ELMIRA SHALE LOAM.

The soil of the Elmira shale loam consists of a light-gray loam, 10 or more inches in depth, containing a large percentage of silt and fine sand. It is mellow, loamy, and easily cultivated. The subsoil, which is found at from 10 to 24 inches below the surface, is much the same in texture and slightly lighter in color, having in certain localities a yellowish cast. The difference in color is in a certain measure due to the presence of a less amount of organic matter. It contains angular shale fragments or bowlders, which occur in such great quantities that it is practically impossible to find a place where an auger hole can be put down for more than 3 feet without interruption.

A stony phase of the type, indicated by gravel symbols on the map, consists of a light-colored loam with a depth of 8 or 9 inches, intermixed with angular shale fragments, varying from 30 to 60 per cent of the whole mass. The interstitial material here, as well as in the typical soil, varies and depends upon the location. It may be either a sandy loam or silt, the coarser material being confined to the center of the flood plain, and the finer to the outer borders. The subsoil of the stony phase contains the same amount of shale as the soil, is much the same in texture or slightly heavier, lighter in color, and is characterized in certain localities by a decided yellowish cast of color.

On a number of farms of the gravelly phase considerable time is spent in picking off the large stones, and in this way much rock is annually removed. In the area lying about 3 miles west of Horseheads the stony phase is well developed and is locally called "Sing Sing" gravel.

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The Elmira shale loam is formed from the washings from the Hagerstown shale loam, and occupies the valley on both sides of Seeley Creek, occurring also along Sing Sing and Newtown and other smaller creeks. Where the creeks have deep-cut canyons with slight fall the soil is deposited in the form of great sloping plains, but where steep channels prevail and the streams are swift large quantities of material are carried down to the valley to be deposited, as the creeks adjust themselves to the more gentle slopes, in the form of fan or cone deltas. It is in the latter areas that the stony phase is found. The stone consists of angular or slightly worn shale fragments. Exceptions, however, were noted where well-rounded bowlders of quartz, sandstone, and other rock had been picked up from the glacial dumps and deposited with the other material.

Besides tobacco, all of the general farm crops are grown, but to obtain the best yields it is necessary to give the soil a liberal application of manure. Especially is this true of the tobacco lands, which require heavy manuring annually. The cultivation of tobacco is attended with good results, even on land that would ordinarily be considered a veritable rock pile. The plants grow well and though not as many pounds per acre are produced as on the Elmira fine sandy loam, the leaf is finer, possesses a better color, and commands a higher price.

The following table shows the texture of samples of this soil as determined by mechanical analyses:

Mechanical analyses of Elmira shale loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6783	¾ mile NE. of Seeley Creek.	Light-brown loam, 0 to 12 inches.	3.07	0.46	1.44	0.80	3.92	32.12	49.42	11.10
6784	1¼ miles E. of Southport.	Light gray-colored loam, 0 to 24 inches.	1.99	1.70	3.60	1.70	3.10	19.54	53.88	16.48
6782	2 miles NE. of Horseheads.	Loam, 0 to 8 inches..	3.23	8.98	6.90	2.40	3.36	9.10	48.68	20.30

HAGERSTOWN SHALE LOAM.

The Hagerstown shale loam is a light-gray or ash-colored friable loam 6 to 8 inches in depth, interspersed with a greater or less amount of angular shale fragments, sometimes reaching as much as 60 per

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cent of the whole mass. The texture of the interstitial material varies slightly with the variations in the character of the rock from which the soil is derived. Where fine-grained shales occur, such as prevail over the greater part of the hills, a silty loam is the resulting material, but where the shaly sandstones are found the soil is a fine sandy loam. The subsoil consists of a lighter colored loam with a yellowish cast, occasionally mottled or streaked with dark gray or blue. It contains a higher percentage of loose, angular shale fragments than the soil, and eventually grades into shale in place.

Excepting a few small and unimportant areas, the type occupies all the hill lands of the Elmira sheet. These hills, ranging in elevation from 900 to 1,900 feet above the sea, cover more than 75 per cent of the area surveyed. On account of the many and varied positions in which the soil is found—on steep and on gentle slopes, in exposed and in protected localities—the depth of soil varies greatly. There are places where the rock outcrops or comes quite near the surface, so that the plow rides on a ledge of shale the entire length of the field. In other places the soil has accumulated to a depth of 3 feet or more. The proportion of loose rock in the soil also depends on the location. Where disintegration is in advance of erosion the greatest amount of soil is found and, vice versa, where the washing is most active the largest amount of rock fragments occur. In many places they exist in such great quantities as to render cultivation difficult, and many have been picked off the fields and thrown in large heaps or piled up in fences, to which latter purpose they are well adapted on account of their flat surfaces. On a few of the low, rounded hills northeast and northwest of Horseheads a slightly different phase of this type occurs, one of the most striking characteristics of which is the small number of stones present. On these hills the soil has about the average depth for the type, but is underlain by a heavier subsoil.

In a number of places on the hills, even on some of the highest points, occasional rounded bowlders consisting of red and white sandstones, quartz, and granite are observed. As there are no local rocks of these varieties the conclusion is that they have probably been transported by glaciers.

On the shale hills in many places the roots of forest trees seem to have been unable to penetrate the soil, but spread out in the shape of broad fans over the surface. In clearing the land large numbers of these stumps have been made into fences, where they have stood for more than forty years and are yet apparently good for many more.

Originally the hills supported a heavy forest of pine, but this has all been removed and all that remains is a small amount of second-growth pine, hemlock, maple, hickory, chestnut, and oak. Little attempt is made to encourage the growth of forests. Trees even less than a foot in diameter are cut to supply the local lumber demand, and

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it is now only a question of a short time when the few remaining trees will be destroyed. In the forested state the hills are in a great measure protected from washing, but when cleared and turned to the plow large quantities of soil and plant food are annually carried away. When first farmed, good crops were harvested and prosperity prevailed throughout the area, as is generally the case with virgin soil, but by years of cultivation the lands have been in a great measure exhausted of available plant food. This is not due so much to the amount removed by cropping as to that which is continually removed by washing and leaching. Another important factor causing a greater depletion of the hill farms than of those of the valley is the fact that they are held in larger tracts and not enough manure is produced to cover more than a small part of the cultivated area, while at the same time their location, making hauling difficult as well as expensive, has prevented the bringing in of manure and fertilizers from outside sources. Tobacco culture has also played its part in impoverishing many of the farms. The few acres devoted to this crop take the greater part of the barnyard refuse to the deprivation of the rest of the land. As the result of these and various other causes the greater part of the hill farms are now in a state where their working is attended with very little profit, and a number of abandoned farms may be seen.

On this soil are raised, as in the lowlands, all the ordinary farm crops, including beans and potatoes, the latter being of a superior quality and keeping exceptionally well.

The following table gives the mechanical analyses of typical samples of this soil:

Mechanical analyses of Hagerstown shale loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6785	1¼ miles W., ¼ N. of Post Creek.	Loam containing silt, 0 to 5 inches..	2.76	4.40	4.26	1.28	2.20	19.12	51.36	17.16
6789	2 miles N. of Sullivanville.	Silty loam, 0 to 7 inches.	2.87	2.02	3.30	1.98	4.10	13.08	53.84	21.36
6787	2¼ miles NE. of Elmira.	Silty loam, 0 to 10 inches.	1.73	2.48	3.06	1.40	1.76	9.12	59.58	22.50
6786	Subsoil of 6785......	Loam containing silt, 5 to 18 inches.	.95	6.64	5.20	1.86	3.40	18.90	46.90	17.06
6790	Subsoil of 6789......	Silty loam, 7 to 18 inches.	.40	1.10	2.62	1.56	3.32	15.96	56.20	19.08
6788	Subsoil of 6787......	Silty loam, 10 to 24 inches.	.32	1.78	3.02	1.64	2.70	5.24	57.42	28.12

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ELMIRA SILT LOAM.

The Elmira silt loam consists of silt loam of a very uniform texture, 6 to 8 inches in depth, and for the most part light gray or ashy in color. This color is materially darkened where the soil is heavily manured or kept in pasture. Under certain conditions of moisture the soil is difficult to plow, forming clods, but taken at the right time it breaks up well and becomes in good tilth. The subsoil, which is at least 40 inches in depth, consists of a dark-yellowish loam, streaked with gray and blue. It is much heavier than the surface soil and offers considerable resistance to the passage of the ground water. This is rather a serious objection, making the land cold, moist, and late, retarding both the planting and the harvesting of crops. This untoward condition has been successfully met by the use of tile drains.

The soil has been formed by the weathering of fine washings from the shale hills brought down by the flooded mountain streams and deposited by slowly moving water. It is either farmed to cultivated crops or used for pasture. All the crops common to the region, such as corn, oats, wheat, rye, buckwheat, and tobacco, are grown. The culture of the last named is most successful on the drained land and on the sandy spots found adjacent to creeks. The tobacco raised, especially on the underdrained soil, attains a good height and yields about as well as on any of the soils of the area. The leaf is large, thin, and suitable for wrapper, and in quality compares favorably with the best produced in the area. The best-colored leaves are raised on the sandy spots. The sandy soil generally matures the crop slightly in advance of the heavier soil.

To produce large crops on the Elmira silt loam it is found necessary to make liberal applications of manure. This is especially true where tobacco is the crop to be grown. As much as one or even two carloads of stable manure per acre are annually applied to the tobacco fields.

The table on the following page shows the texture of typical samples of the soil and subsoil of this type.

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Mechanical analyses of Elmira silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct
6780	1¼ miles NE. of Bigflats Station.	Fine sandy loam, 0 to 10 inches.	3.27	0.16	1.02	1.46	3.90	30.06	50.00	12.86
6776	¾ mile W. of D., L. and W. Station, Bigflats.	Light gray silty loam, 0 to 8 inches.	2.60	.20	.60	.40	.86	12.64	67.32	17.46
6778	1 mile NE. of East Corning.	Silt loam, 0 to 10 inches.	2.62	1.46	3.98	1.88	3.42	3.14	50.84	35.12
6781	Subsoil of 6780......	Fine sandy loam, 10 to 40 inches.	.27	.24	.48	.42	1.22	25.44	59.96	11.48
6777	Subsoil of 6776......	Heavy silt loam, 8 to 40 inches.	.34	.00	1.30	.70	.66	12.34	65.72	18.60
6779	Subsoil of 6778......	Heavy silty or clay loam, 10 to 40 inches.	.42	.58	1.56	.62	.94	7.82	62.02	25.52

PEAT.

The Peat is dark brown or almost black in color and consists of vegetable matter in various stages of decay. It varies in depth according to location, the deposit being deepest in the center of the areas, where it occasionally has a thickness of 8 or more feet. It is always loose, incoherent, and very easy to till.

All the areas of this type are found in the valley and lie to the north of Elmira. They occur for the most part as small, irregular patches and streaks in depressions where the water table is either at the surface or within a short distance of it. Originally these spots, with a few exceptions, were covered by small, shallow ponds or lakes fed by springs and favoring the growth of tules, reeds, and other water-loving plants. Here the decaying plant remains slowly accumulated from year to year until the ponds were filled and in places covered over with deposits more than a foot in depth. Several ponds may be seen at present in part or completely overgrown with swamp vegetation, and it is only a question of time, if the growth is not interrupted, when they too will be converted into peat areas.

Before the Peat can be cropped drainage is generally found necessary. This is done by a system of underground tile or open ditches from 2 to 4 feet in depth, which lower the water table sufficiently to permit thorough cultivation. The cuts or ditches along the boundary lines show the Peat to be underlain with blue silty clay. On account of the boggy nature of this soil, it is found necessary to put supporting shoes on the plow horses. These are made of flat pieces of

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iron or steel about 12 inches in diameter, and are attached to the foot by means of two clamps that lock over the front of the hoof. It is said the horses have some difficulty at first in using these shoes, but soon become accustomed to them. The fact that such shoes are necessary gives an idea of the miry character of this soil type.

To a limited extent the peat has been dried and used in the stables and barnyards as an absorbent and afterwards applied with good results to tobacco lands.

Celery is the principal crop grown on Peat, to the cultivation of which it is peculiarly adapted, large crops being harvested annually. (See Pl. I, Fig. 2.) Cabbage, onions, and some farm crops are also grown and give large yields, but as their cultivation is not confined to the muck areas and is not as profitable, these products generally give way to celery.

MEADOW.

This term is used to designate lands too moist for cultivation without drainage, occurring in small narrow areas adjacent to swamps, springs, and water courses. Such areas are generally covered with a growth of grass and used mostly for pasturage. The texture of the soil varies according to location. On the hills adjacent to springs and swamp depressions it is for the most part a dark-colored loam about 8 inches in depth, underlain with a heavy subsoil. Near the streams the texture is lighter, containing more silt and sand. In all of these areas shale fragments are occasionally found in the surface soil and to a greater extent in the subsoil. In the lowland or valley the soil consists of a silty clay 11 inches or more in depth underlain with blue sand.

AGRICULTURAL METHODS.

In the Bigflats area much care is exercised in the preparation of the soils for planting. They are all thoroughly plowed, an average depth of 6 inches being deemed necessary for all the ordinary crops, which include corn, wheat, oats, rye, buckwheat, timothy, potatoes, and clover, while special care is given in preparing the soil for tobacco and celery.

On some of the most successful tobacco farms the land is plowed in the fall and seeded to rye or wheat, which is allowed to grow until about May of the following year, when it is turned under for green manure. Where the fields are subject to overflow, this winter growth, in addition to fertilization, gives considerable protection to the surface, keeping it from washing by checking the velocity of the flood waters and causing the deposition of much alluvium, which also enriches the soil. The tobacco plants are raised in hothouses or beds and set out in fields that have been thoroughly plowed, harrowed, and rolled. Mechanical planters, drawn by horses and constructed to mark the row and cover and water the plants at one operation, greatly facilitate

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transplanting. From one-half acre to 1½ acres can be set in this way in one day by a man and two boys. (See fig. 2.) As soon as the plants take root and begin to grow they are cultivated, and cultivation is repeated as often as necessary until the crop matures. When the tobacco begins to bud, the button is pinched out, which forces the energy into the leaves and stalk buds. The latter rapidly develop into shoots or suckers, all but one or two of which are removed. This number is sufficient to keep the plant growing and the leaves in good condition. As the plants mature they are cut and hung in sheds, where they remain until thoroughly dry. They are then taken down in damp weather and the leaves stripped off and tied in bundles or packed in boxes ready to be sold. The price varies from 5 cents to 18 cents per pound. In most cases the sorting is left to the buyer, but occasionally it is done by the farmer.

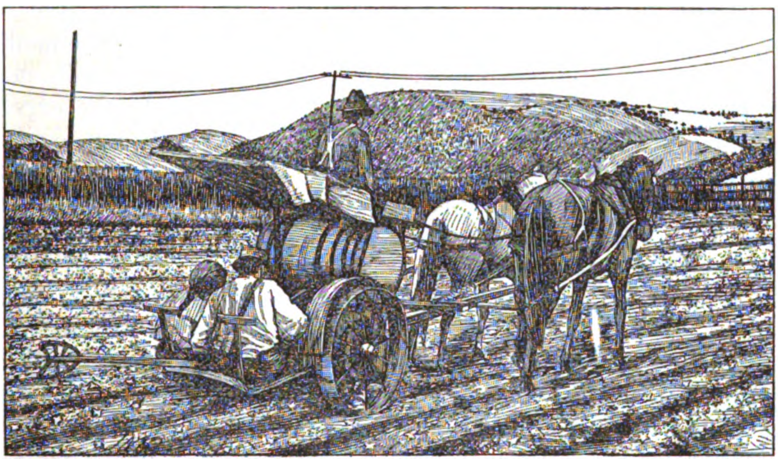

FIG. 2.—Tobacco setter used in the Bigflats area.

Tobacco here as elsewhere is attacked by several insects that feed on the leaves, impairing the quality and lessening the yield. The grasshopper is one of the worst enemies of the tobacco, and entire fields are occasionally destroyed by this insect, though the damage is usually less severe than this, merely lessening the value of the crop.

Celery plants, like tobacco plants, are raised in hot beds or hothouses and set out in well-tilled ground as soon as the weather permits. The plants are put in by hand in rows about 3 feet apart, 15,000 or 16,000 plants being used to the acre. The fields are always kept in good tilth, and when the celery attains sufficient height it is banked for blanching. Harvesting begins the latter part of August. The plants are tied up in bunches of one dozen each, and bring about 21 cents per dozen bunches. The bulk of the crop goes to supply the local and nearby markets.

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The planting, cultivating, and harvesting of the other crops are carried on here as elsewhere. The methods are too well known to need repetition.

The apple orchards, which usually consist of an acre or two around the houses, are really side issues. The crop is so uncertain that many think it unworthy of much attention. If fruit comes, well and good; if not, nothing is lost. Practically all that is done in caring for this crop is to occasionally plow the ground and prune the trees. The codling moth and forest, tent, and apple-tree caterpillars do no little damage, and, unless thorough spraying is resorted to, when there is any fruit it is badly worm-eaten.

To keep the soils in a productive state it is found necessary to fertilize them generously. Not only is all the manure produced on the farm applied annually, but this is supplemented where convenient by a large quantity hauled from nearby towns in wagons or brought in by railroad in carload lots. The latter consists largely of stock-car scrapings, etc., and is sold on the siding for $28 per car. The hauling of manure is only practiced in the valley, where it can be easily done. The hill farmers are in a great measure handicapped by the expense in getting outside manure. Their efforts should therefore be confined to increasing their home supply, first, through caring for what they have by not allowing it to leach and wash away, as it now does in many places, and, second, by increasing the number of live stock kept and selling them instead of crops.

The most manure is used on the tobacco and celery soils. On the former 30 to 60, and even 90, cubic yards are applied to an acre. The results are very apparent, and the increase in yield is said always to pay for the increased cost of fertilization. On all of the crops except tobacco one kind of manure does not seem to be much better than another, but in the case of tobacco horse manure is preferred, as it gives a lighter-colored leaf. The use of commercial fertilizers on tobacco, excepting the cotton-seed products, is seriously objected to by the buyers, for in many cases the burning properties and flavor of the leaf are so seriously impaired as to make it worthless.

Rotation is not practiced in celery production and only occasionally where tobacco is grown. Tobacco in many places has been grown from six to ten years on the same field without intermission. Occasionally, however, the lands are sown to wheat in the fall, seeded to clover in the spring, and planted to tobacco the following season with good results. Where potatoes are the main crop a two-year rotation with clover is found to be very beneficial. Where hill lands can not be fertilized or seeded to clover, which is in time replaced by timothy, the soil where turned to the plow can be farmed with good results for one or two years, but then must be put in grass and used for pasture.

The rainfall is generally sufficient for the ordinary farm crops.

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There are, however, occasions when irrigation would be beneficial. In several places where lands lie adjacent to creeks the water has been diverted and used with good results. Within the area surveyed there are many farms where water could be turned upon the land at little expense, and the uncertainty of moisture supply could be eliminated from crop production.

AGRICULTURAL CONDITIONS.

The prosperity of an agricultural community depends upon the fertility of the soil and its adaptation to crops, the proximity of the region to markets and to transportation facilities, and the intelligence and energy of the people themselves. In the area covered by this survey the condition of the farmers in the valley is as a rule more prosperous than in the hills. There are, however, exceptions in both regions. Poorly kept places are found in the lowlands, due to the stony and worn-out condition of the soil or to the occupancy of an unenergetic farmer, while good farms here and there in the hills show to what extent wise husbandry and hard work can compensate for natural deficiencies in soil and location. The less thrifty appearance of the upland farms is also partly due to the fact that many more are tenanted than in the valley. Tenancy is rarely conducive to the maintenance of soil fertility or to the improvement of farm property generally.

Taking the area as a whole, the farming class is in a prosperous condition. The well-kept and well-fenced farms, improved by good and comfortable houses, and the barns and other buildings for housing the stock, covering the machinery, and curing the tobacco, attest this.

The size of the farms varies according to location. In the vicinity of the towns lands are, as a rule, more valuable and the tracts are not so large, being used more as homes than as places on which the owners are dependent for sustenance. Excluding these, 50 valley farms in the vicinity of Horseheads show an average size of 97 acres, with a valuation of about $40 per acre, while the same number of hill farms give an average of 134 acres, assessed for taxation at a little over $13 per acre. As some of the best valley lands lie outside of this district, $40 per acre can not be taken as the average value, which is probably nearer $100 per acre.

The labor of the farms is principally done by the farmers themselves, and therefore is the most efficient that could possibly be obtained. In some cases children, women, and old men all join in helping during the busy season. The hired help work practically on a basis of social equality with the proprietors, and are thus placed where they will do the most and best work. The wages paid labor ranges from $15 to $20 per month, including board, or $1 per day without board.

While tobacco is the principal crop, the average field does not exceed

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4 or 5 acres, and it must not be supposed that the farmers depend entirely upon it. Their success comes from a number of sources. On all of the farms some live stock, consisting of horses, milch cows, hogs, and sheep, are kept. It is the policy to make the farm produce all the forage necessary for their maintenance, including pasturage, ensilage, hay, and grain. Dairying is carried on to a limited extent by many of the farmers, some of whom keep as many as 30 cows. The milk is sold to local creameries or to dealers who have milk stations in the cities. The average price received by the dairyman is 2 cents per quart. To obviate the necessity of each producer delivering his milk, general routes are established and a man gathers all the milk in his district and carries the cans to the station and returns empty ones on his way home.

Local truck gardens supply the town and city demands during late spring and summer, while in the country each family is furnished from the home garden. Small orchards of apples, pears, cherries, plums, and peaches, and a few grapevines are also a part of the resources of the farmer.

Good roads prevail everywhere. Even in the hill region, where the slopes are very steep and the ravines rough, they are seldom if ever impassable. The great aid they are to the successful practice of agriculture is too well known to need discussion.

Four main lines of railroad pass through the area, and with their many stations and sidings offer accommodations both in the reception and in the rapid delivery of freight to the large markets such as are enjoyed by few agricultural communities. A trolley line with a half-hour service also traverses the area from Elmira, through Horseheads and Pine Valley, to Watkins, facilitating traveling and freighting and adding much to the convenience of those along the route.

Elmira, the principal town in the area surveyed, is a growing city with a population of more than 35,000. It is the site of several colleges and has a public library and many other educational advantages. Elmira is the headquarters of a number of tobacco dealers, who buy and handle the greater portion of the tobacco raised in the area. The city is also a good market for much of the farm produce of the surrounding country.

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SOIL SURVEY OF THE LYONS AREA, NEW YORK.

By W. EDWARD HEARN.

LOCATION AND BOUNDARIES OF THE AREA.

The Lyons area, lying largely within Wayne County, in the western part of New York, about midway between Rochester and Syracuse, covers an area of approximately 515 square miles, or 339,664 acres. It is comprehended between the parallels 43° and 43° 20′ north latitude and the meridians 77° 15′ and 76° 45′ west longitude.

The area borders upon Lake Ontario for a distance of 26 miles and extends south for about 22 miles. It is crossed by the Erie Canal and the New York Central Railroad. Lake Ontario is the most eastern of the great inland seas which divide the United States from Canada. The part of the lake bordering this survey has only one embayment, namely, Sodus Bay, which is quite a good harbor.

Newark is the largest town in the area surveyed, while Lyons, Clyde, and Palmyra are enterprising places and of some importance as markets for the farm produce of the region. (See fig. 1.)

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The Indians of the Iroquois Confederacy, or what is known as the Six Nations, were the first inhabitants of this area in historic times. They lived in a rude manner, depending for sustenance chiefly upon hunting and fishing. Their main crops were corn, potatoes, and vegetables. With the exception of a few scattered fields and occasional swamps and meadows the land was covered by dense forests, consisting of beech, elm, hickory, oak, ash, hemlock, white pine, and sugar maple. Of all this thick forest very little is left to-day.

The first white settlers entered this area abont 1790, coming chiefly from the New England States, although some were from Scotland. During the period of 1809–1815 a few Quakers came in from Pennsylvania. The tide of immigration continued almost constant, and was only slightly checked by the war of 1812.

The inducements to settlement were cheap lands, extended in area, and the prospective increase in value by reason of situation on a waterway and not distant from the eastern markets. There were two classes of settlers—those who were purchasers of land and those who were simply squatters. The latter found employment, but rarely

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became landowners by prescription. The land at first was cleared by cutting out the brush and deadening the trees by girdling, and later by felling and burning the timber. Even the choicest timber had no value in those days except for the ashes left upon the fields after the fires. The great labor required to clear the primeval forests of this part of the country, even in this wasteful way, can hardly be appreciated.

The first crops were corn, potatoes, wheat, rye, oats, the common vegetables, and a little tobacco for home use. All these crops yielded well on the fertile virgin soils. On the hills by the streams the pioneer settlements were first made. The streams at that time were the only highways, and here gristmills and sawmills were soon built.

Prior to the completion of the Erie Canal produce was taken to Albany on sleds in winter and by boats in summer. Sheep raising was practiced considerably up to 1850, but since that time there has been a gradual but constant decline in this industry. The Merino has been the principal breed. Dairying also had an early beginning and this interest has continually increased to the present time.

The Erie Canal, connecting Lake Erie with the Hudson River, greatly benefited the farming class, causing freight rates to decrease about 90 per cent. In 1853 the New York Central Railroad was built from Rochester to Syracuse.

By this time the agriculture in this area had become more diversified. Fruit growing had come to be one of the main industries. A little later peppermint became a quite important money crop. At that time peppermint oil brought a good price and had a ready sale at Lyons, but in recent years the price has been low, and at the present time only a little is produced in the area surveyed. A few years ago barley was also considered a staple crop in the northern portion of the area, but now almost none is grown.

Agricultural societies and fairs have long been important institutions in this region and have done much to stimulate the farming classes to activity and progress. Step by step needs have been met and advances made. Changes in methods of cultivation, a greater variety of crops, and improved machinery have given the farmer command of his fields, and to-day in its dwellings, barns, home conveniences, and improvements generally the area stands out as one of great agricultural progress and prosperity.

CLIMATE.

The following table, compiled from the records of the Weather Bureau stations at Lyons, Rochester, and Oswego, shows the normal monthly and annual temperature and rainfall, based on observations covering periods of eleven, thirty, and thirty years, respectively. Lyons, situated in the center of the southern portion, and Rochester, only 21 miles from the western boundary of the area, represent quite

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well the conditions in the central and southern part of the survey. Oswego, situated on Lake Ontario, about 20 miles east from the eastern boundary of the survey, is believed to indicate fairly well the climatological conditions of that portion of the area bordering Lake Ontario.

Mean monthly and annual temperature and precipitation.

Month.	Lyons.		Rochester.		Oswego.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	Inches.	°F.	Inches.	°F.	Inches.
January	26.5	2.61	23.9	3.14	24.3	2.97
February	25.6	2.36	24.4	2.73	24.6	2.54
March	32.5	2.62	30.3	2.86	30.4	2.62
April	46.3	1.49	43.5	2.48	42.3	2.08
May	57.5	3.15	56.3	3.34	54.0	2.83
June	67.5	3.21	66.4	3.22	64.0	3.40
July	70.5	3.27	70.4	2.97	69.0	3.12
August	69.4	3.57	68.4	3.06	68.2	2.64
September	62.7	2.77	62.0	2.34	61.7	2.80
October	51.1	2.40	49.9	2.92	50.0	3.26
November	40.1	2.92	37.4	2.85	38.5	3.37
December	31.1	2.76	28.6	2.91	29.4	3.39
Year	48.4	33.13	46.8	34.82	46.4	35.02

An examination of this table shows that the rainfall is fairly uniformly distributed throughout the year, the greatest amount of precipitation, however, occurring during May, June, July, and August.

PHYSIOGRAPHY AND GEOLOGY.

The surface features of the Lyons area are greatly diversified, being composed of a succession of hills and valleys. The elevation ranges from 250 to 700 feet above sea level. The southern and central parts of the area are broken by hills and ridges running north and south. As a rule these terminate in abrupt slopes to the north, while to the south the slope is more gradual. The ridges rise some 100 to 160 feet above the intervening valleys. The northern part of the area possesses a more rolling surface, which inclines northward to the lake. There are, however, some prominent ridges in the northeastern corner of this part of the area.

Only a few of the hills and ridges are so precipitous as to prevent cultivation. There is in the northwestern part of the area, about 5 or 6 miles distant from the lake, a stony and gravelly ridge that has the appearance of an ancient beach, being composed in part of waterworn gravel and bowlders. This ridge forms a part of the drainage divide separating the waters entering Clyde River and those running into Lake Ontario. An arm of the Montezuma Marsh, covering about 10 square miles, occurs in the southeastern part of the area.

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The central and southern parts of the Lyons area are drained by the Clyde River and its tributaries, while the waters of the northern part run into Lake Ontario. The drainage divide is not well marked, the land being practically level where the small streams head.

Clyde River, formed by the junction of Ganargua Creek and Canandaigua Outlet at Lyons, is the principal stream in the survey. The valley along this river is generally narrow and is flanked by hills and ridges on each side. A few of the smaller streams which have sufficient fall afford water power, which is utilized by gristmills. Many of the small streams have cut deep and very narrow channels. Some terracelike formations occur in places along these streams, and in the vicinity of the New York Central Railroad such terraces furnish an excellent gravel for road ballast.

The soils in this area are derived from glacial drift composed, at least in part, of material brought from the country to the north by the great ice sheet which during the Ice Age covered this part of the American continent. The depth of this drift over the bed rock ranges from a few feet to about 100 feet. The upland soils of the area contain a large percentage of rounded stones and gravel, and in many places large, erratic bowlders, chiefly granite and retaining signs of glacial action, are scattered through the drift. The valley soils, after considerable modification by stream action, have been redeposited, and are free from stones and gravel.

The rocks that underlie this glacial material at varying depths are of Silurian age, and are chiefly sandstones and shales.

All the central and southern part of this area is underlain by the Salina shale. This is seen outcropping at the base of the hills in a few places. The strip of country from Marion to Sodus Center and thence east to Wolcott and south to Butler Center is underlain by the Niagara limestone, which also outcrops in several places. It has, however, but little influence upon the soils in this survey. Some of the limestone rock is quarried and manufactured into lime.

The remaining part of the area is underlain by the Clinton and Medina formations. The former consists of limestone and shale; the latter is a red sandstone and is confined to the lake front.

SOILS.

There were mapped in the Lyons area seven types of soil, exclusive of Meadow and Muck. The distribution of these types, while following certain broad, general laws, is very intricate, and the accurate tracing of the boundaries was a labor of more than ordinary difficulty. The predominant soil is the Miami stony loam, occupying a little less than one-half the area. The extent of none of the other types exceeds 12 per cent of the area.

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An interesting feature of the soil map is the graphic way in which it illustrates the action of the glacial ice, the areas lying in the majority of cases with their longer axis parallel with the direction of the motion of the ice. The soil is thus seen to occur in grooves or hollows scoured out by the great ice mass, or in ridges between these grooves, filled in or built up by glacial drift, by detritus, and by washed and transported material.

The following table gives the total area of each type of soil and the proportion which each bears to the entire survey:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami stony loam	158,400	48.4	Miami fine sand	14,656	4.4
Alton stony loam	38,208	11.6	Miami loam	5,184	1.5
Meadow	35,008	10.6	Muck	3,840	1.1
Miami fine sandy loam	29,824	9.0	Total	329,664	....
Elmira silt loam	28,096	8.5			
Alloway clay	16,448	4.9			

MIAMI STONY LOAM.

The surface soil of the Miami stony loam is a light-brown sandy loam, having a depth of 7 to 10 inches and containing occasional streaks of gravel, the proportion of which ranges from 5 to 40 per cent of the soil mass. The subsoil is a yellowish or brown sandy loam to a depth of 3 feet, containing from 5 to 50 per cent of gravel and stones. In a few instances the clay content increases with the depth of the soil. There are scattered areas of this type which are underlain by a consolidated mass of gravel forming substantially a hardpan. In most cases this hardpan is not sufficiently near the surface to interfere with cultivation or to exert any influence on the crops. The stones and gravel are composed chiefly of granite with a less quantity of sandstone fragments, generally small and well rounded. This material occurs in the greatest abundance in the more rolling areas of this soil, while as a rule the proportion is comparatively insignificant on the steepest slopes and hills. This peculiar distribution may in part be due to the alternate freezing and thawing of the land in winter and to the cultivation of the soil, both of which would have a tendency to move the stones from the steep to the more level areas. The stones in some cases have been picked off and piled in heaps, or, where they occur in sufficient quantity, used in fencing the fields.

The Miami stony loam is the most important type found in the present survey, both in extent and agricultural value. Its most important development is found in the southern and central parts of the area surveyed, where it occurs in broad and extended areas of irregular

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outline. Quite a number of small bodies of this soil are found in the northeastern part of the area, and scattered areas occur in other localities.

The Miami stony loam has a very much broken and diversified surface. It occupies the hills, knolls, ridges, and, occasionally, the gently rolling country. This soil has the highest elevation in the area, the altitude ranging from 450 to 700 feet above sea level. A great number of the ridges occupied by this soil have quite abrupt slopes and are cultivated with difficulty.

The natural drainage of this type is good. Scarcely any part of it has to be ditched, and underdrainage is unnecessary. It is a comparatively warm soil and one that can be tilled shortly after a rain.

The origin of the Miami stony loam may be traced to the weathering of the glacial drift material. The hills and ridges occupied by this type are the immense deposits left by the ice as it receded, or by the glacial streams swollen by the waters from the melting ice.

At least 90 per cent of this soil is under cultivation. Excepting the more stony fields and steep places, it is easily tilled. The stones and the declivities interfere considerably with the use of modern farm machinery.

Upon this soil is grown to some extent every farm crop known to the area. The principal crops are the grasses, corn, oats, wheat, sugar beets, and potatoes; while relatively less important are cabbages, beans, green peas, peppermint, tobacco, and berries. Timothy and clover are the main grass crops, and these yield from 1 to 2½ tons per acre. Corn gives about 25 bushels, wheat 12 bushels, oats 25 bushels, and potatoes about 75 bushels per acre. The yield per acre of sugar beets averages between 8 and 11 tons. The beet contains a high percentage of sugar with a satisfactory purity of juice. The cultivation of green peas and of cabbages is found quite profitable. The peas yield from three-fourths to 1½ tons per acre and are grown for canning purposes. Cabbages average from 4 to 12 tons per acre. (See Pl. IV, fig. 2.) A few fields of tobacco were seen north of Savannah. The peppermint is grown for the most part at the base of the hills, where the soil is more moist and slightly finer textured than in the more elevated areas. Patches of raspberries and blackberries were seen, and these fruits are profitably grown. The growing of tree fruits forms a very important part of the agricultural practice and many large apple orchards and a few cherry, pear, plum, and peach orchards occur on this soil.

The Miami stony loam is not especially adapted to any one crop in preference to others, but can be relied upon as a good, safe soil for general farming.

The table on page 149 gives the mechanical analyses of typical samples of Miami stony loam.

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Mechanical analyses of Miami stony loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7426	1¼ miles NE. of Marion.	Brown sandy loam, 0 to 9 inches.	1.90	1.22	3.36	3.84	16.26	24.40	41.02	9.14
7424	1¼ miles N. of Lyons.	Brown sandy loam, 0 to 10 inches.	1.67	2.58	3.74	3.44	16.26	24.70	37.90	10.98
7428	2¼ miles S. of Palmyra.	Brown sandy loam, 0 to 9 inches.	2.32	3.08	5.30	4.62	16.44	19.56	38.64	11.84
7427	Subsoil of 7426	Yellowish sandy loam, 9 to 36 inches.	.94	1.82	3.71	3.96	17.42	25.54	38.54	8.72
7429	Subsoil of 7428	Brown sandy loam, 9 to 36 inches.	1.74	4.62	7.34	5.90	18.76	18.92	31.16	13.30
7425	Subsoil of 7424	Yellow sandy loam, 10 to 40 inches.	.71	1.90	3.06	3.52	17.82	24.14	34.54	14.84

ELMIRA SILT LOAM.

The Elmira silt loam is a pale-yellow to light-brown silt loam, carrying a relatively high percentage of very fine sand. The soil has a depth ranging from 6 to 12 inches. Below this is found a brown or chocolate loam, slightly heavier in texture and extending to a depth of 36 inches. Road cuts and stream banks show the subsoil to be several feet in thickness. In a few instances the subsoil has streaks or layers of very fine sandy loam scattered through it.

This soil type is confined to the northern and northeastern part of the area surveyed. Excepting the smaller patches scattered along Lake Ontario, the soil occurs in broad and extended areas.

There is a great diversity in the surface features of the Elmira silt loam. It occupies the rolling forelands of Lake Ontario and the tablelands, ridges, and steep slopes bordering Sodus Bay and the several small streams that empty into the lake. Some areas of this soil on the steepest slopes are badly gullied.

The soil generally has good natural drainage, but in some of the more level parts and depressed areas it is inclined to be cold and heavy, and these places would be benefited by underdrainage.

The uniformity in the texture of this soil and the position it occupies are evidences that it was laid down in comparatively quiet water, and that since that time it has undergone but little change. The surface, however, has weathered to some extent, having become slightly lighter in color and of a more mellow nature. It gives soft, smooth roads, a characteristic of this soil easily detected in traversing the area.

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The Elmira silt loam is a light and mellow soil, easily tilled and free from stones or gravel, except the few scattering stones occurring where this soil joins the Miami stony loam. It is subject to quite heavy erosion, but this can in great measure be prevented by proper cultivation. Most of the silt loam is under cultivation and produces good crops. The yield per acre of wheat is from 10 to 20 bushels, of oats from 20 to 40 bushels, of corn from 15 to 30 bushels, of potatoes from 60 to 150 bushels, and of timothy hay from 1½ to 2½ tons. Raspberries and blackberries do well. Some of the finest apple orchards in the area were observed on this soil around Sodus Bay, where also are smaller orchards of peaches, pears, plums, and cherries. (See Pl. III, fig. 2.) A few years ago large crops of barley were raised on this soil, but this crop has now been abandoned.

The silt loam has the power of retaining large quantities of water, and hence it can withstand drought exceedingly well—much better than any of the other upland soils in the survey. It holds fertility fairly well and can be easily improved.

The following table shows the texture of typical samples of the Elmira silt loam:

Mechanical analyses of Elmira silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7420	3 miles N., ¾ mile E. of North Wolcott.	Yellow silty loam, 0 to 8 inches.	0.78	0.16	0.88	0.72	3.86	21.32	63.66	9.06
7418	1¼ miles N., ¾ mile E. of Alton.	Yellowish silty loam, 0 to 10 inches.	2.43	.10	1.04	.78	2.98	21.62	60.14	12.76
7422	¾ mile W. of Resort.	Light brown silty loam, 0 to 9 inches.	1.11	.00	1.14	.92	1.80	13.10	69.86	12.82
7419	Subsoil of 7418	Yellowish silty loam, 10 to 40 inches.	.18	.26	1.12	.84	1.56	22.36	63.18	10.08
7423	Subsoil of 7422	Light brown silty loam, 9 to 36 inches.	.30	.02	.64	.78	1.76	10.04	72.78	12.92
7421	Subsoil of 7420	Yellow silt loam, 8 to 36 inches.	.47	.00	.42	.36	2.80	13.64	68.34	13.70

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MIAMI FINE SAND.

The Miami fine sand is a fine yellow or light-brown sand, with an average depth of about 8 inches, underlain by a subsoil of fine orange or yellow sand extending to a depth of 40 inches. Both soil and subsoil are generally free from stones, although a little gravel is scattered over the surface in a few localities. The light-brown color of the soil is due to the organic matter that has been incorporated with the mineral particles. From sections in road cuts the Miami fine sand is seen to be several feet deep, the material being quite uniform throughout.

Areas of this soil type occur in the north central and northwestern parts of the survey and along the Rome, Watertown, and Ogdensburg division of the New York Central and Hudson River Railroad, in the vicinity of Williamson. Smaller scattered areas occur in other parts of the survey.

There is but little uniformity in the surface features of the Miami fine sand. It occupies the rolling upland, level areas, knolls, and ridges indiscriminately, and is usually found near the courses of the small streams emptying into Lake Ontario or Sodus Bay.

Owing to its texture and the rolling position it occupies this soil has good natural drainage. Both the surface and seepage waters are quickly carried away. Indeed, so thoroughly and rapidly is the water removed that cultivation can be carried on immediately after a rain, when all the surrounding soils are too wet to be tilled.

The Miami fine sand consists, originally, of glacial material. This has been partly reworked, and in many cases redeposited, by the streams, to the sorting action of which is due its uniformity of texture.

This soil is very early and is easily tilled. The principal crops are corn, potatoes, and berries. Some wheat, oats, hay, and cabbages are produced. One or two fields of tobacco were seen. Corn yields moderately. Potatoes do well, averaging from 50 to 130 bushels per acre. The tubers are of medium size, smooth and clean, keep well, and possess a fine texture and flavor. The culture of raspberries is quite extensively practiced on this soil and a good yield is obtained. Several young orchards of peaches, pears, cherries, and plums, as well as larger and older orchards of apples, were seen on this soil.

The Miami fine sand is adapted to truck, potatoes, and small fruits. All these crops do well and can be more profitably raised than the ordinary farm products. The soil is leachy, does not retain fertilizer well, and consequently it can not reach a high state of productiveness. It can, however, be much improved by applications of well-rotted barnyard manure and by turning under some leguminous crop. These methods would increase the humus in the soil and make it more retentive of moisture.

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The following table shows the texture of the Miami fine sand:

Mechanical analyses of Miami fine sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7399	2¼ miles NW. of Sodus.	Light brown fine sand, 0 to 7 inches.	2.35	0.20	0.84	0.68	9.18	67.36	19.24	1.10
7395	1¼ miles SE. of Alton.	Light brown fine sand, 0 to 9 inches.	2.43	.38	.48	1.38	36.32	47.34	11.32	2.54
7397	2 miles SW. of Marengo.	Yellowish sand, 0 to 8 inches.	1.66	.20	9.90	13.94	41.70	17.16	10.52	5.24
7400	Subsoil of 7399......	Yellowish fine sand, 7 to 40 inches.	.47	.18	.48	.40	5.80	76.70	14.94	.78
7396	Subsoil of 7395......	Yellowish fine sand, 9 to 40 inches.	.28	.02	.04	.06	40.40	52.84	5.00	1.64
7398	Subsoil of 7397......	Yellowish sand, 8 to 40 inches.	.38	.50	8.20	11.46	46.70	21.70	7.72	3.36

MIAMI LOAM.

The Miami loam to a depth of 10 inches consists of a dark-brown silty loam. The subsoil is either a silty or clay loam of brown color, extending to a depth of 36 inches. Both soil and subsoil are free from stones or gravel. It is an easily tilled soil.

Areas of this soil occur in the central southern portion of the survey along Clyde River, in the vicinity of Alloway, and in a few scattered patches along Ganargua Creek to Palmyra.

The Miami loam occupies the level river and stream bottoms and has the same general surface features throughout. It is never over a few feet above the water level. By reason of this low position the drainage is naturally poor. Artificial drainage can be advantageously applied to a part of the areas.

The soil consists of glacial material, worked over by the smaller streams and finally deposited by Clyde River and the larger creeks. Each year this soil is being built up and enriched by fresh deposits left by the streams at times of flood.

The Miami loam is a strong, fertile soil. It is recognized as one of the best soils for the ordinary farm crops in the area surveyed, though liability to flooding during the growing season considerably lessens its value. Sugar beets do well on this soil, producing as high as 18 tons per acre, with an average yield of from 12 to 14 tons. Corn and oats yield from 30 to 60 bushels per acre. Wheat and the grasses also do well. Some peppermint is also grown, and the soil seems well fitted to the production of this crop. All these yields are dependent

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FIG. 1.--HARVESTING A CROP OF ONIONS ON SMALL MUCK AREA, LYONS AREA, NEW YORK.

This represents one of the large special industries, and shows a peculiar adaptation of a soil to a crop.

FIG. 2.—AN APPLE ORCHARD ON THE ELMIRA SILT LOAM, LYONS AREA, NEW YORK.

Wayne County is one of the five large apple counties of New York. The principal apple soils are Lyons silt loam and Lyons stony loam.

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FIG. 1.—A CROP OF NAVY BEANS ON THE ALTON STONY LOAM, LYONS AREA, NEW YORK.

The illustration shows the very stony character of the soil. This is a far less productive soil than the Lyons stony loam, although the reason for this is not apparent.

FIG. 2.—CABBAGES ON THE MIAMI STONY LOAM, LYONS AREA, NEW YORK.

This is one of the important crops of the area, and this is one of the most important soils, adapted to vegetables, apples, and dairying.

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upon a favorable season and freedom from overflow during the growing of the crops.

The natural fertility of the Miami loam is such that little or no fertilization is needed to produce good crops. This fertility is annually added to by the overflows taking place during winter and early spring. The soil is best adapted to wheat, corn, oats, grass, and sugar beets.

The following table shows the texture of the soil and subsoil of this type:

Mechanical analyses of Miami loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7432	3¼ miles SE. of Lyons.	Dark brown loam, 0 to 12 inches.	4.47	0.00	1.04	1.50	6.26	11.64	61.08	18.40
7430	1¼ miles S., 3¼ miles E. of Lyons.	Brown silty loam, 0 to 9 inches.	2.25	Tr.	.94	1.44	5.14	12.98	56.36	22.38
7431	Subsoil of 7430......	Brown silty loam, 9 to 40 inches.	1.21	.00	.62	1.26	6.28	36.44	40.20	14.92
7433	Subsoil of 7432......	Brown clay loam, 12 to 36 inches.	2.33	Tr.	1.94	3.24	6.62	6.04	51.30	27.72

MIAMI FINE SANDY LOAM.

The surface soil of the Miami fine sandy loam consists of a brown or black, mellow, fine sandy loam with a depth ranging from 5 to 10 inches and containing in many cases a high percentage of organic matter. The subsoil is a fine to medium, yellow, gray, or white sand with a depth of 3 feet or more. Occasionally strata of sandy loam a few inches thick are found in the subsoil. Both the soil and subsoil are free from stones and gravel, except in a few places adjacent to the stony loams, where a comparatively small proportion of such material is found mixed with the soil. A few small areas of this type are more nearly a silt loam.

This soil type occurs in broad extended areas in the eastern central part of the survey, just west of Clyde and Rose, in small areas in the vicinity of North Rose, Alton, Sodus, and Newark, and in many smaller patches scattered throughout the survey. In the central areas the soil occurs in strips between the Miami stony loam and the Alton stony loam.

There is considerable uniformity in the surface characteristics of the Miami fine sandy loam. It occupies the very gently rolling, level, and low-lying areas bordering the smaller stream courses. The elevation is generally below the surrounding soil areas.

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This soil has for the most part very poor natural drainage, and the largest and most typically developed areas badly need underdrainage. This can be had by the use of terra cotta tiles. In its present condition the soil is late and cold, but with proper drainage this disadvantage would be largely overcome. Not only would a larger yield of the crops now grown be secured in this way, but the soil would become adapted to a greater variety of crops, and its value would be enhanced accordingly.

The Miami fine sandy loam consists of glacial material which has been greatly modified by stream action. Part of it is probably the finer material which has been washed from the surrounding stony loams and sands.

On this soil are grown chiefly corn, wheat, oats, grasses, sugar beets, potatoes, peppermint, onions, and osiers. Sugar beets do only fairly well on this soil, producing a moderate yield, ranging between 8 and 10 tons to the acre, although the sugar content and purity are quite high. The culture of osiers is said to be profitable on the wetter areas of this soil. Some fields were noticed just northeast of Lyons. Onions do fairly well where the soil has a high proportion of organic matter. Small patches of peppermint were also noted. This yields from 15 to 20 pounds of oil per acre. Few fruit trees were seen on this soil.

The Miami fine sandy loam is too light to give the best results in growing the grains and grasses. When drained it should be used for potatoes, sugar beets, onions, and other like specialties, while the wetter areas, particularly those difficult and expensive to drain, must continue to be best adapted to osier willow and peppermint production.

The following table shows the texture of samples of the soil and subsoil of this type:

Mechanical analyses of Miami fine sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7405	1 mile NW. of Rose.	Dark fine sandy loam, 0 to 10 inches.	1.62	0.02	0.32	0.30	10.34	51.72	32.96	4.20
7403	¾ mile NE. of Newark.	Black fine sandy loam, 0 to 8 inches.	7.54	.60	2.68	6.86	38.02	20.78	26.18	4.82
7401	½ mile NW. of Alton.	Brown fine sandy loam, 0 to 8 inches.	2.17	.10	.90	.62	4.00	54.30	32.02	6.84
7402	Subsoil of 7401......	Yellowish sand, 8 to 40 inches.	.70	.56	1.04	.62	1.46	52.30	40.50	3.44
7404	Subsoil of 7403......	Yellowish fine sand, 8 to 36 inches.	.41	.40	1.94	8.58	54.20	24.46	5.56	4.34
7406	Subsoil of 7405......	Yellow sandy loam, 10 to 40 inches.	.71	Tr.	.60	.40	19.28	53.34	19.78	6.46

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ALLOWAY CLAY.

The Alloway clay is a silty or clay loam of grayish or dark-brown color, 4 to 8 inches deep, underlain by a subsoil of mottled-yellow or grayish clay, having a depth of 3 feet or more. In a few instances the subsoil is underlain by quicksand at a depth of 30 inches. Both soil and subsoil are free from stones.

The only large area of this soil lies just northwest of Clyde. There are, however, many small areas, or patches, scattered over the southern part of the area surveyed.

In this area the Alloway clay is always found in low, level, or depressed areas, and in many cases it borders the small streams. The similarity of position produces quite uniform surface features.

This soil, owing to its low position and the close, impervious nature of the subsoil, has very imperfect natural drainage. Underdrainage would considerably improve its mechanical condition and at the same time make it warmer and more easily tilled.

The Alloway clay is sedimentary in origin, being derived by deposition in very quiet water of the finest material which has been washed out of the surrounding soil formations.

This soil produces good crops of wheat, oats, corn, and hay. Sugar beets and cabbages are also grown to some extent. It is said that the sugar beets have no trouble in penetrating the clay subsoil of this formation, and fairly good yields are secured, but the sugar content is not quite so high as in the beets grown on Miami stony loam. Very few fruit trees are seen on the Alloway clay.

In adaptation this type is an excellent grain and grass soil. It also makes good pasture land.

The following table gives the mechanical analyses of typical samples of the soil and subsoil:

Mechanical analyses of Alloway clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7407	1¼ mile NW. of Clyde.	Dark-gray silty loam, 0 to 7 inches.	5.34	0.04	0.44	0.48	2.72	9.80	65.12	20.98
7409	¼ mile N., 1¾ miles E. of Newark.	Dark brown clay loam, 0 to 7 inches.	5.41	.20	.78	.98	4.50	9.98	47.98	35.10
7408	Subsoil of 7407	Clay loam, 7 to 30 inches.	.48	.34	1.24	.94	6.40	11.88	55.18	23.68
7410	Subsoil of 7409	Clay, 7 to 36 inches.	.65	.32	1.06	.90	2.84	6.70	36.26	51.74

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ALTON STONY LOAM.

The surface soil of the Alton stony loam is a silty or sandy loam of grayish or brown color, having a depth of 6 to 10 inches and containing from 25 to 50 per cent of stones and gravel. The subsoil is either a sandy loam of brown color or a clayey sandy loam of reddish color, each containing from 20 to 60 per cent of stones and gravel. The stones and gravel found in this soil type are chiefly fragments of granite, brown sandstone, and limestone. The fragments are of all sizes, but are generally from 3 to 6 inches in diameter. There are, however, many large, erratic granite bowlders scattered over the surface of this soil, some fields being so covered by them that cultivation is impossible. Some of the stones have been picked up and piled in heaps, built into fences—a characteristic feature of the farms on this soil—or even used in the construction of buildings. (See Pl. IV, fig. 1.

This soil is confined to the northern part of the area surveyed, occurring in the largest and most typically developed areas around Wolcott and Williamson. Many smaller, scattered areas lie between these places, especially along the line of the New York Central and Hudson River Railroad.

There is a somewhat general uniformity in the surface features of this soil. It occupies chiefly the rolling and the practically level uplands, but now and then an area is found on a hill. It occurs for the most part at elevations ranging from 290 to 450 feet above sea level—a much lower position than that occupied by the Miami stony loam.

The more rolling areas of this soil have good natural drainage. Generally it is in the more level areas that the subsoil is the heaviest, and these would be benefited by underdrainage.

This soil consists chiefly of superficially weathered glacial material, but a very small proportion of the area is residual in origin, being derived from the decomposition of outcrops of the Clinton and Niagara limestones. The residual phase of this type is quite rich in lime.

The Alton stony loam, as a rule, is the poorest soil in the area. The more gravelly portions are leachy, can not withstand drought, and are tilled with considerable difficulty. Some areas, however, produce fairly good crops. Beans, corn, wheat, oats, and hay are the main products, with potatoes, cabbage, buckwheat, berries, and grapes as secondary productions. Beans are quite extensively grown on this soil, giving yields ranging from 12 to 25 bushels per acre. Apples do well; also peaches, pears, plums, and cherries. Grapes do fairly well, but are not grown to any great extent. This soil is adapted to fruit, especially apples, and should be devoted exclusively to its culture.

The table following gives mechanical analyses of soil and subsoil of this type.

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Mechanical analyses of Alton stony loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7411	3 miles SW. of Pultneyville.	Grayish sandy loam, 0 to 8 inches.	4.70	0.66	2.20	1.46	6.34	44.70	33.24	11.06
7415	1½ miles SE. of North Wolcott.	Dark loam, 0 to 7 inches.	3.94	2.24	4.80	3.58	18.06	24.50	34.74	11.76
7413	2 miles NW. of Sodus.	Brown loam, 0 to 10 inches.	3.03	1.34	3.78	2.62	16.58	39.50	21.04	14.82
7414	Subsoil of 7413......	Brown sandy loam, 10 to 36 inches.	.59	1.60	3.84	3.38	18.00	30.50	24.00	18.12
7416	Subsoil of 7415......	Reddish clay loam, 7 to 36 inches.	.84	.64	2.78	2.68	17.56	23.88	32.98	19.40
7412	Subsoil of 7411......	Reddish sandy loam, 8 to 36 inches.	.40	.14	1.38	.68	3.08	39.58	34.98	20.16

MEADOW.

The Meadow in the present survey includes all the flat, low-lying land occurring along the banks of streams and in springy places, which is too wet for cultivation. The soil is either a fine sandy loam or a clay, having scattered through it a few patches of muck. The area comprised in the arm of the Montezuma Marsh contains some muck, which is underlain in a few places by marl. The largest area of the Meadow is found in the southeastern part of the area surveyed, while many smaller areas and strips are found in other localities, especially near Wolcott, in the vicinity of Joy, and on each side of the Clyde River. The low position this land occupies makes it impracticable for it to be drained, either by open ditches or underground drains.

Part of the Meadow is forested with a growth of elms, while the remainder is used chiefly as pasture, affording good grazing for the cattle during the drier months. Some of the areas produce a coarse hay, and the only part that is cultivated is planted to osiers. These do well on this land and are a profitable crop.

During wet seasons a large part of the Montezuma Marsh area is covered with a luxuriant growth of flags, while in dry seasons the same area produces hay. During the last two years a number of tons of these flags have been cut, cured, bundled, and sold, bringing from $20 to $25 per ton loaded on cars at the nearest railroad station. The flags grow from 4 to 8 feet high, and the stems are quite uniform in size. They are cut by hand, as the land is partly covered by water and too mucky to support horses and machinery. One man can cut, cure, bundle, and market about 1 ton a week. The chief use made of

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these flags is for the bottoms and backs of fine chairs. Should this industry continue, a very handsome profit can be had from land heretofore considered practically worthless.

MUCK.

The Muck consists of vegetable matter more or less thoroughly decomposed, mixed with a small proportion of very fine sand and clay. It is of a dark brown or black color, and has a depth of 40 inches or more, except in a few narrow strips along the edges, where the soil is from 15 to 40 inches deep, underlain by a subsoil of fine sand or clay. In many places the Muck is from 6 to 10 feet deep.

This soil type occurs in small bodies and long strips in the central western portion of the area surveyed, in the vicinity of Minsteed, and in a few patches in other parts of the area. It occupies the level, low-lying land along the small, slow-moving streams, and the inclosed, depressed areas between the hills and ridges where drainage outlets are insufficient or altogether lacking.

On account of its position the soil has scarcely any drainage. Before it can be cultivated it is necessary in every case to cut ditches through the areas sufficiently deep to collect and hold, even if they can not rapidly remove, the water drawn from the upper part of the soil. Fortunately, the nature of the soil is such that ditches are easily constructed and are of considerable permanence.

The Muck soil is due to lack of drainage. The soil is formed through the filling in of ponds or shallow lakes by the accumulation of decayed vegetation, particularly the remains of tules, flags, and other water-loving plants. The soil is therefore naturally rich in nitrogen, to such an extent even as to make it profitable to add it to the hill soils commonly deficient in organic matter.

About two-thirds of the area of Muck is under cultivation and produces large crops. The remainder is covered with a growth of trees or thick grass and is too wet for farming. The area unreclaimed, when cleared, ditched, and exposed to the sun, can be cropped profitably. The yield of onions from this soil ranges from 150 to 700 bushels per acre, with the average yield not far from 400 bushels. Potatoes grow very large, but they are apt to be hollow or to be attacked by black heart. The keeping quality is also poor. Some celery is also grown with fair results.

In this area the Muck is especially adapted to onions and celery, and its cultivation can be most profitably carried on if exclusive attention be given to the production of these two crops. (See Pl. III, fig. 1.)

AGRICULTURAL METHODS.

Compared with methods in the West and South, agricultural practices in this area are intensive. Most of the cultivable areas are con-

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stantly cropped, even the steepest slopes and the roadside areas being utilized. The usual rotation is corn or potatoes, oats or barley, winter wheat, and clover. This scheme, however, is not very closely followed.

Corn and potatoes are planted in checks and cultivated both ways, generally with a fine-toothed cultivator drawn by one horse. Oats are usually sown broadcast; wheat and barley with drills. Clover, alone or mixed with timothy, is sown in the wheat in the spring. Permanent meadows of timothy are also seen. Chiefly red clover is grown, but crimson clover is used to some extent.

Stable manure is highly valued, and is carefully saved and spread on the fields. Usually this is done by hand, but it would seem that the machine spreader would probably prove a paying investment to the farmers of large tracts.

Hay, an important product of the Lyons area, is cut in most instances with horse mowers and manipulated by horse tedders and rakes. The partly cured grass is thrown into small cocks overnight, or during wet weather spread again in windrows, recocked, and so on until a perfect cure is effected. Handled in this way, the hay preserves a fresh, sweet smell and a bright, clean color.

A great part of the oats, wheat, and barley raised is harvested with sweep reapers, many hillsides being too steep for successful operation of the more cumbersome binder. Moreover, many of the farms are too small to make it economical to own so expensive a machine.

Green peas are sometimes sown broadcast, but more often drilled, mowed like hay when at the right state of maturity, and hauled to the canning factory, where they are shelled by machinery. The vines are often returned to the farm and preserved in silos. Beans are planted in rows and cultivated with horse cultivators. When mature they are pulled up by the roots, dried, and shelled by machinery.

Peppermint is grown from the roots of the preceding crop. These are dug out in the spring, laid in rows in the field, and covered. Shoots soon appear, which are cultivated as any other crop. At maturity the mint is cut, wilted, and the oil distilled from the plants by passing steam through them. The steam, carrying with it the oil, is then condensed, and the oil, which rises to the top, is easily separated.

The heavier soils are found best for sugar beets. The fields are usually subsoiled for this crop. The seed is sown from May 1 to June 20, using not less than 12 pounds to the acre. It is sown with drills in rows 20 to 24 inches apart. When young the seedlings require a great deal of hand labor. They are usually bunched with a narrow hoe when about 1 inch high, and are later thinned by hand. Afterwards the crop is cultivated with horse implements, the large fields with specially constructed sugar-beet cultivators. Those commonly in use are one-horse machines, which scrape the ground between two rows of beets at one time. The beets are harvested by loosening

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the ground near the roots with a subsoil plow, and pulling and topping by hand. Practically all the beets are grown under contract, and are delivered at the factory in Lyons or at some convenient shipping point.

Orchards are sometimes cultivated, especially when young, but are generally kept in grass.

Cabbages are started in beds. When of the proper size the plants are set in the field with transplanters, very similar to those used for tobacco, drawn by horses. Cultivation of this crop is also done with horse implements. The plants are usually set in rows 3 feet apart and about 18 inches apart in the row, making 7,000 to 9,000 plants per acre.

Onions are usually raised from sets planted in rows about 1 foot apart and tilled with hand cultivators.

AGRICULTURAL CONDITIONS.

Throughout the Lyons area the farming class is, as a rule, in a prosperous condition. The dwellings, for the most part, are well-constructed frame buildings, neatly painted, while a few more substantial brick and stone buildings are seen. The last are made of smooth, rounded stones about 4 or 5 inches in diameter, and are a characteristic feature of the northern part of the area.

Many large, roomy barns, capable of housing all the live stock and with room in addition for storing hay and grain crops, are seen on the larger and more valuable farms. These barns are generally painted red. On most farms are also evaporator houses, corncribs, onion and potato bins, and shelters for farm implements and carriages. The fences are board, wire, and stone, with occasionally an osage-orange or thorn hedge. Nearly every farm is supplied with good horses, several milch cows, and a few hogs. Here and there a flock of sheep is kept, but the industry is declining.

The land is so closely cultivated and pastured that scarcely any forest exists, except on the areas of meadow. Over three-fourths of the farmers heat their houses with coal, and all the evaporating of fruit is done with that fuel.

About 75 per cent of the farms covered by this survey are owned and tilled by the farmers themselves. The rest are cultivated by two classes of tenants, one of whom pays a cash rental, or a stated amount of labor or farm produce for the use of the land, the other a stated proportion of the crops produced. In the hands of tenants the farms are apt to decline in fertility, for the tenants as a rule make little or no attempt to improve the land, or even to maintin its natural productiveness.

The farms vary in size from 20 acres to over 200 acres, the average size being 70 acres. Around the towns and villages the areas are

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smaller and the price per acre very much higher. The Miami stony loam brings from $20 to $100 per acre. The Miami loam also brings a good price, while the Muck is the most valuable land in the area.

One great difficulty in operating the farms in this area arises from the scarcity of labor. The foreign classes, chiefly Italians, are about the only kind of labor that can be secured. Some of them are good workers, but the majority do not understand the work or take much interest in the welfare of their employers. The great demand for farm help naturally makes wages high, and the farmers frequently must pay $1.50 per day for ordinary field labor, and at times it can not be had at any price. A great variety of crops is grown in this area, but the mainstay of agriculture is fruit, especially apples (the money crop), grass, corn, oats, wheat, sugar beets, potatoes, onions, and cabbages, while the less important crops are green peas, beans, peppermint, celery, tobacco, buckwheat, raspberries, grapes, and blackberries. The cultivation of these has been outlined and yields given in the description of the several soil types and in the chapter on agricultural methods.

The sugar-beet industry is comparatively new, but is growing and deserves more particular mention. The beets are grown on all the soils in the central and southern portion of the area, and good yields are secured, being especially good on the Miami loam and Miami stony loam. The Miami loam gives the largest yields, while the beets grown on the Miami stony loam contain the highest percentage of sugar. The sugar-beet company contracts with the farmers to buy the beets, paying up to this time $5 per ton delivered at the factory.

The area included in the present survey lies within the apple belt of western New York, and is probably, in quantity and quality of the fruit produced, as important as any area of equal size in this region. Many large orchards occur throughout the area, but the industry centers in the northern part, within the zone of the lake influence. There are in the aggregate about 700,000 apple trees in the orchards of the Lyons area. The trees bear a full crop every other year and a partial crop in the intervening years. All the choice fruit is sold green; the inferior is dried, or made into cider and sold as cider or as vinegar. Houses for evaporating the fruit are seen near every large orchard. Here the fruit is peeled, cored, and sliced by machinery and dried on trays by artificial heat.

The Lyons area also ranks high as a producer of small fruit. In addition to the apple orchards many smaller and generally younger orchards of peaches, pears, plums, and cherries are to be found. These fruits also find a ready sale for cash. Several large fruit-tree nurseries are located in the area, important ones being found in the country south of Newark.

Dairying is carried on to a considerable extent. There are no very

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large herds of dairy cattle, yet nearly every farm keeps milch cows, and the milk in excess of home demands is sold either to the creameries located here and there in the area or is shipped to the cities.

Some commercial fertilizer is used, but not to any great extent. The great renewer of fertility is barnyard manure, immense quantities of which are made and carefully preserved and added to the fields.

The Elmira silt loam, the Miami stony loam, and Alton stony loam are generally recognized as the best soils for fruits. The Miami stony loam and Miami loam are considered fairly good land for sugar beets. The Miami fine sand is an ideal soil for truck and small fruits, but as yet is not generally recognized as such. It is used to a great extent for potatoes. Muck soil is especially adapted to onions and celery and should be devoted entirely to their culture.

The New York Central Railroad, the West Shore Railroad, and the Erie Canal pass through the southern part of the area, while the Rome, Ogdensburg and Watertown Division of the New York Central and Hudson River Railroad crosses the northern part. There is also the Northern Central Railway, from Sodus Bay southward through the area. All of these furnish good facilities for transportation of the produce of the area, and are a great stimulus to its industries and an important factor in its prosperity. There is also one trolley line in operation, which carries freight. In addition to the railroad transportation facilities, good dirt roads lead out in every direction from the chief market towns. These roads are in fair condition the greater part of the year, and are easily traveled except on the steepest hills and the more sandy places. They are built and maintained at the expense of the county.

Another great convenience to the farmers is the free delivery of mail in rural districts, which system is in operation throughout the survey. Many grocery wagons cover the country, supplying the people with needed articles of food.

There are no large cities in the area, but the towns of Newark, Lyons, Clyde, Palmyra, Wolcott, and Sodus offer some market for farm produce. Creameries are located at all of these places and handle most of the milk produced within the area. Some of these points have canning factories for green peas and corn. Apples and pears are mostly sold directly to purchasing agents of firms in large cities, who come into the territory and buy the product prepared for shipment and delivered at the railroad station. Berries and small fruits that are not consumed within the area are shipped by express to the large cities, some railroads even running special trains for this purpose. The sugar-beet factory is located at Lyons and at this time handles all the beets produced. There is also a firm there which buys peppermint oil. In general this area is so well supplied with railroads that all the surplus products can be easily and quickly placed in the important markets of the large Eastern cities.

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SOIL SURVEY OF THE TRENTON AREA, NEW JERSEY.

By R. T. AVON BURKE and HENRY J. WILDER.

LOCATION AND BOUNDARIES OF THE AREA.

The area surveyed lies in the western central part of New Jersey and includes a small part of Pennsylvania bordering the Delaware River near the city of Trenton. The area is comprised within the meridians 74° 21′ and 74° 49′ west longitude and parallels 40° 5′ and 40° 35′ north latitude. The extent of the area is about 810 square miles or 518,464 acres. The survey includes parts of Hunterdon, Somerset, Middlesex, Mercer, Monmouth, Burlington, and Ocean counties, New Jersey, and Bucks County, Pennsylvania.

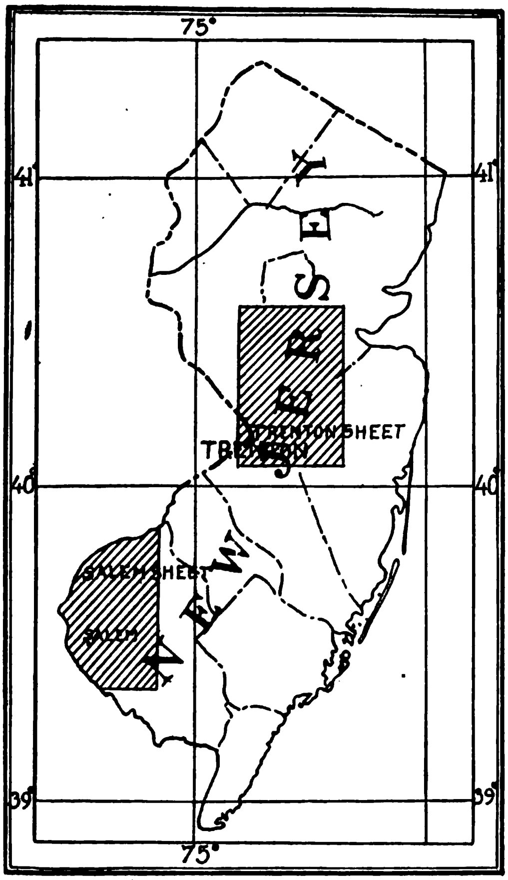

Fig. 3.—Sketch map showing areas surveyed in New Jersey.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The present State of New Jersey was originally part of the grant given by King James in 1606, under the title Virginia. It was occupied at that time by different tribes of the Delaware Indians. In 1609, Henry Hudson, driven ashore by storm, explored the country inland as far as what is now Monmouth County. The first settlement in New Jersey, however, was that made under direction of the Dutch West India Company in 1623, when the fort at Nassau was built. In

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the same year other Dutch settlements were founded along the Delaware.

Soon after this Gustavus Adolphus made a claim to the territory and sent out a colony composed of Swedes and Finns. They landed at Henlopen and bought of the Indians a tract of land extending from the coast to the falls near Trenton.

In 1640 the first English settlement was effected by a few families who took up lands along Salem Creek. Fourteen years later the Dutch overcame the Swedes and held possession of all the settled territory until 1664, when the English overthrew the Dutch rule. By treaty, however, the Dutch and Swedish settlers were allowed to remain practically unmolested. The country around Perth Amboy in the meantime had been settled by the Scotch. The same year Lord Berkeley and Sir George Carteret, by deed of the Duke of York, became sole proprietors of New Jersey. In the early days all lands were bought of the Indians before they were settled upon.

The soils were considered good, but variable, producing all kinds of small grains, indian corn, flax, and hemp. The barrens were used for grazing. Fruits, such as grapes, plums, apricots, peaches, pears, apples, quinces, and melons, were raised in abundance.

The earliest exports were horses, pork, beef, lumber (pipe staves and boards), flour, wheat, barley, rye, corn, butter, and cheese. Trade in these commodities was principally with Jamaica, the Barbados, the Canaries, and other islands, and also with Spain and Portugal. Oil and furs were shipped to England.

CLIMATE.

From the data available it would seem that there is considerable local variation in the climate and in the effect of climate upon the condition of the soils and upon the crops and agricultural practices in different parts of the Trenton area. The ocean's influence—greater as the ocean is approached—the differences of altitude, the level or broken topography, and the texture of the soil are the principal factors in this variation. In the country of rolling topography, and particularly in the vicinity of Creamridge, both the condition of surface drainage and the character of the soil tend to produce washing, while the clayey soils bake and clod badly under the heat of the summer sun. In Ocean County, the location of sandy soils, the extremes of daily temperature occur, and agriculture suffers most from drought and from erratic late and early frosts. The hill country is less likely to suffer damaging droughts, although there also many of the soils are light and open textured. In the area where the red shale formation occurs crops suffer from the hot, dry winds of the summer season, while in the trap-rock ridge the average temperature

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is somewhat lower, and the slopes are often cold and wet with seepage waters.

In the following table the normal temperature and rainfall, based upon official records covering a period of ten years, are given for four stations, beginning with Freehold, in the eastern part of the area, and ending with Trenton, in the western.

Normal monthly and annual temperature and precipitation.

Month.	Freehold.		New Brunswick.		Somerville.		Trenton.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° *F.*	*Inches.*	° *F.*	*Inches.*	° *F.*	*Inches.*	° *F.*	*Inches.*
January	29.7	4.16	29.5	3.82	27.9	3.76	33.4	3.55
February	31.4	3.86	29.3	3.64	30.1	3.99	34.9	3.60
March	37.6	4.69	38.8	3.99	38.5	3.81	40.9	4 49
April	47.9	3.56	50.1	3.68	50.0	3.05	53.7	3.61
May	60.0	3.77	61.4	4.02	61.3	4.28	65.2	3.92
June	69.2	2.99	80.7	3.80	70.2	3.88	74.5	3.94
July	73.2	4.32	76.3	4.92	74.9	4.89	78.9	5.53
August	71.4	4.45	73.9	4.93	74.1	4.17	76.9	5.17
September	64.9	4.94	67.0	3.94	67.7	3.37	68.8	4.05
October	53.2	3.47	55.1	3.45	54.4	3.08	57.2	3.87
November	42.6	4.05	43.3	3.93	43.4	4.51	46.8	4.18
December	33.9	3.43	33.3	3.57	33.6	3.69	37.6	3.43
Year	51.2	47.69	57.3	46.69	52.2	46.48	55.7	49.34

The prevailing wind movement, also on a basis of records covering a period of ten years, is from the northwest in the winter and southwest in the summer season. From observations during the survey the general rains are usually accompanied by northeast or southeast winds, while the thunder showers usually come from the northwest.

The average dates of killing frosts for the four stations are as follows: Freehold, spring, April 15; fall, October 16. New Brunswick, spring, April 15; fall, October 14. Somerville, spring, April 26, fall, October 9. Trenton, spring, April 12; fall, October 16.

PHYSIOGRAPHY AND GEOLOGY.

The country presents a beautiful and varied topography. Those areas more resistant to disintegration and decomposition stand out in prominent relief, showing the close relationship between the physical features, as wrought by atmospheric agencies, and the underlying geological formations. This relationship is particularly striking in the northern part of the area, where the trap-rock ridge and Sourland Mountain break through the rolling country of the Brunswick shale formation and rise in bold outlines to a height of 500 feet above sea level.

Although the differences are not so pronounced in the unconsoli-

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dated area—the Coastal Plain—there is still considerable variation. In the sand areas of Ocean County the general level is only relieved by occasional gravel-crested hills. Another part of the Coastal Plain, occupied by the Cretaceous-Eocene formations, rises in a series of partially detached, steep-sided hills which extend from Creamridge to the hills northeast of Manalapan. These hills rise to an elevation varying from 160 feet to 300 feet above sea level, and form the most important drainage divide of the southern part of the area surveyed. The Cretaceous-Eocene reaches north and southwest to the gently undulating Pleistocene uplands and east to the dissected areas of the Pensauken formation.

A line of contact extends through the area, dividing the consolidated formations of the Triassic and Trenton-Philadelphia gneiss from the unconsolidated series of the Atlantic Coastal Plain. This divide extends in a generally northeast and southwest direction from Trenton to New Brunswick. Of the Triassic formations the Brunswick shales have the widest distribution. The rock itself is of an Indian-red color and is generally a soft and crumbling shale or argillite. It gives rise to the slightly undulating topography of the northwestern part of the area.

The Trenton-Philadelphia gneiss does not outcrop sufficiently to influence the character of the soils of the area. It generally comes to the surface along the deeper stream courses in the vicinity of Trenton, and along Stony Brook southwest of Princeton. In the neighborhood of Trenton it is covered with Pleistocene deposits, which form the Sassafras loam.

The trap ridge, Jura-Trias in age, consists of very hard, massive rocks varying from diabase and gabbro to gabbro diorite. It owes its position to the intrusion of a dike through the shale formation. This ridge, which varies in elevation from 100 to 300 feet above the general elevation of the surrounding country, is usually covered with large bowlders. The rock outcrops along Lawrence Brook, northwest of Fresh Ponds, and also southwest of Deans. Here it modifies slightly the character of the soil of this vicinity, which as a result has been correlated with one of the upland soil types. In the vicinity of Metuchen, southwest along the Raritan River to New Brunswick, Franklin Park, and Rockyrill, is found a remnant of glacial material, consisting of stones and pebbles of quartzite and chert, varying from one-half inch to 6 inches in diameter, many of them bearing the marks of glacial striation. This heterogeneous drift, reworked with the Brunswick shales, gives rise to one of the most important soil types of the area.

The Coastal Plain series owes its origin to the deposits of glacial material in marine waters as offshore sediments at a time when the land surface was much lower than at present. The deposits consist of

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alternate layers of gravel, sand, and clay laid down in horizontal beds. The succession is very often interrupted and modified, as changes in elevation or deposition occurred, but generally they follow in a definite order.

Where exposed these deposits, under the agencies of erosion, general surface weathering, and the reworking of material by wave or stream action—each separately or all combined—have resulted in a variety of soil types varying widely in character and fertility.

SOILS.

The Trenton area is one of varied soils, there being fourteen distinct types besides Meadow shown on the map accompanying this report. All of these soil types have been found in preceding surveys. The subjoined table gives the total area of each of these soils and the percentage which each is of the whole area:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Penn loam	171,712	33.1	Penn sandy loam	10,816	2.1
Sassafras loam	84,672	16.3	Quinton sandy loam	8,640	1.7
Collington sandy loam	83,456	16.1	Penn stony loam	5,632	1.1
Norfolk sand	50,880	9.8	Sassafras gravelly loam	3,712	.7
Meadow	44,800	8.6	Westphalia sand	1,408	.3
Elsinboro fine sand	26,176	5.1	Windsor sand	512	.1
Cecil loam	13,952	2.7	Susquehanna gravel	192	....
Alloway clay	11,904	2.3	Total	518,464	....

SASSAFRAS LOAM.

The Sassafras loam is a dark-yellow or brown loam, with an average depth of 12 inches, underlain by a heavy loam or clay to a depth of 3 feet or more. The subsoil usually rests on a layer of gravel. The content of sand varies and in a few places the soil tends toward a sandy loam. This soil is found typically developed in the vicinity of Cranbury Station, Prospect Plains, Windsor, Newton, and Jamesburg. It also occurs on the divide between Lawrence Brook and South River, and on Northwestern Ridge, between Englishtown and Jamesburg.

The Sassafras loam is generally found occupying the level or gently rolling divides, ridges, and uplands of the central part of the area. The drainage is generally good.

This soil is sedimentary in origin and owes its comparatively wide distribution to the fact of its recent deposition, being one of the last sediments laid down. It was formed during Pleistocene time, when the part of the country occupied was submerged in the sea. The material composing the soil was transported from land areas farther

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north. There is great similarity between the material making up this soil and that derived from the shale formation between Princeton and Trenton, which seems to point to a like origin in both.

The Sassafras loam is used chiefly for general farming. It is particularly well adapted to dairying. Corn, oats, wheat, and potatoes all produce good crops. The yield of corn varies from 35 to 70 bushels per acre, according to condition and cultivation of the land; oats from 35 to 50 bushels; wheat from 20 to 35; and potatoes from 75 to 150 bushels. Hay yields from 1 to 2 tons per acre. These yields represent the average range and are a fair indication of the productiveness of this type of soil. When the soil is in the best condition and heavily fertilized much larger yields are secured.

The potatoes grown on this soil are not so good as those produced on the Collington sandy loam, nor is the stand of rye or clover so heavy, but grass usually does well and makes excellent pasture of a permanent character.

Of the fruits the apple has shown a particular affinity for this soil, and its cultivation has in the past been quite successful, but many of the orchards are rapidly going to ruin, generally as a result of carelessness.

The following table shows the texture of the soil and subsoil of the Sassafras loam:

Mechanical analyses of Sassafras loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7601	1 mile S. of Newton.	Brown loam, 0 to 10 inches.	1.45	2.26	8.28	6.30	9.94	10.08	53.38	8.80
7605	Cranbury	Brown loam, 0 to 8 inches.	1.67	2.28	9.16	7.50	24.54	8.72	37.70	9.90
7603	1¼ miles N. of Oldbridge.	Brown loam, 0 to 10 inches.	2.70	2.10	6.20	6.98	10.54	10.70	52.54	10.38
7607	1 mile S. of Lawrenceville.	Clay loam, 0 to 6 inches.	2.40	.84	4.20	4.08	11.80	15.24	45.94	16.98
7602	Subsoil of 7601	Compact loam, 10 to 36 inches.	.98	1.48	5.80	5.64	10.56	11.34	49.16	15.70
7604	Subsoil of 7603	Compact loam to yellow clay, 10 to 33 inches.	1.63	2.64	8.76	7.60	8.76	8.52	46.16	17.18
7608	Subsoil of 7607	Loam, 6 to 36 inches.	.90	1.70	4.10	4.32	12.84	14.42	42.72	19.48
7606	Subsoil of 7605	Compact loam, 8 to 36 inches.	.84	1.90	6.48	5.80	17.40	8.88	35.80	23.58

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SASSAFRAS GRAVELLY LOAM.

The Sassafras gravelly loam is a medium to coarse sand containing a large percentage of rounded gravel varying from one-half inch to 6 inches in diameter. The subsoil consists of the same material, which at a depth usually between 24 and 36 inches becomes somewhat sticky or loamy, and finally grades into sand or gravel.

The Sassafras gravelly loam occurs upon the sloping uplands or along the larger stream courses between Jamesburg, Hightstown, and Monmouth Junction.

This type owes its origin to the outcropping of the gravel bed underlying the Sassafras loam, or is the result of general surface washing or erosion. It is found in narrow streaks in conjunction with the Sassafras loam, and the contact between the two is indistinct, owing to their gradual blending.

The soil is usually well drained, but not droughty. Good crops of rye, clover, and potatoes are grown, but this type is especially well adapted to the stone fruits and grapes.

The following mechanical analyses show the texture of soil and subsoil of the fine earth of the Sassafras gravelly loam:

Mechanical analyses of Sassafras gravelly loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7609	1 mile S. of Prospect Plains.	Gravelly loam, 0 to 18 inches.	1.41	12.10	20.64	17.20	11.92	7.30	19.20	11.00
7611	1 mile SW. of Hoffmans.	Sandy loam with gravel, 0 to 10 inches.	.45	2.22	10.80	17.94	19.84	10.62	24.14	14.36
7610	Subsoil of 7609......	Gravelly clay, 18 to 36 inches.	.57	5.52	17.70	21.20	19.64	5.44	12.60	16.96
7612	Subsoil of 7611......	Gravelly loam, 10 to 36 inches.	.43	7.14	14.50	15.20	23.12	6.24	6.98	26.60

COLLINGTON SANDY LOAM.

The Collington sandy loam is a red, brown, or yellow sandy loam, having a depth of 20 inches, underlain by a sticky sandy loam of the same or lighter color. This grades into a yellow or greenish-yellow clay resting upon a greenish or orange sand. Throughout the soil occur pipes and veins of iron crust, and occasionally the surface is strewn with iron-stained gravel. Although typical in all parts of the area mapped, the surface soil differs slightly with the state of decom-

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position of the greensand, from which most of the soil is derived, with the position occupied, or with the length of time it has been under cultivation. These are local conditions which commonly influence the value of all soils, but in the case of the Collington sandy loam they are more pronounced than common and are the main factors influencing its value as an agricultural soil.

The Collington sandy loam occupies a larger area than does any of the other types found in this section of the Coastal Plain. It is practically confined to the middle, eastern, southern, and southeastern parts of the area surveyed, in the vicinity of Perrineville, Clarksburg, the Red Valley, Creamridge, Arneytown, and Ellisdale. There is also an area south of Englishtown.

The original material of this type is the greensand of the Cretaceous age, from which the soil has been derived either directly as a result of decomposition, or indirectly from these sands reworked. This type is found at all elevations and has a rolling or hilly surface.

Where the soil is deepest light farming and trucking are practiced to advantage; where thinner, grass and grain give excellent results, although generally this soil is best adapted to the production of corn, rye, and potatoes. The yields of corn vary from 35 to 70 bushels per acre. With rye an average yield of 20 bushels is secured, but 35 bushels have been produced under good general conditions and heavy fertilization. The production of potatoes on this type is very successful. This crop is at present practically limited to the area in the vicinity of Allentown and Hightstown. The average yield is 150 bushels per acre, but nearly 300 bushels per acre have been produced. Potatoes grown on this soil are earlier and of a better quality than those grown on the Sassafras loam, although not quite so good or so early as those produced on the Norfolk sand.

In the southern part of the area this soil is largely used for dairying purposes, as the soil is a little thin and the clayey subsoil near the surface. The yield of hay will average about 1½ tons to the acre, which is a little less than the Sassafras loam produces. The grass does not last as long as on the latter type, although a much better stand of clover can be secured.

Where this soil occurs in the more hilly country it is adapted to the production of the Kieffer pear. The color of this fruit is not so good nor the yield so large as in the Norfolk sand, though superior to the product of the Collington sandy loam of the lower levels.

The table on page 171 gives mechanical analyses of the soil and subsoil of this type.

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Mechanical analyses of Collington sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct*	*P. ct.*
7574	1 mile SW. of Machaponix.	Brown sandy loam, 0 to 18 inches.	1.07	1.34	8.64	27.84	35.62	15.24	7.22	3.86
7576	1 mile N. of Perrineville.	Coarse sandy loam, 0 to 24 inches.	.58	1.20	19.68	34.80	27.22	4.06	7.06	5.90
7572	½ mile W. of Davis..	Brown sandy loam, 0 to 9 inches.	.94	1.14	8.64	18.02	22.92	10.62	20.04	18.38
7575	Subsoil of 7574......	Greenish-yellow clay, 18 to 36 inches.	.63	.56	4.50	16.36	28.08	16.20	20.10	14.20
7573	Subsoil of 7572......	Sticky sandy loam, 9 to 36 inches.	.32	.64	8.06	18.78	28.38	14.00	13.78	16.36
7577	Subsoil of 7576......	Sticky sandy loam, 24 to 36 inches.	.68	1.02	20.44	31.12	22.06	2.38	5.08	17.90

NORFOLK SAND.

The Norfolk sand is a gray, orange, or red sand of medium to coarse texture, usually having a depth exceeding 3 feet. Throughout the soil are found occasional gravel and clay strata, and oftentimes, especially in the higher elevations, iron crusts formed by the cementing of the sand by soil solutions. Occasionally on the surface and in the soil coarse rounded gravel occurs, varying from one-quarter to one-half inch in diameter. This material is derived from the cross-bedded sands and gravel areas of the deltas, particularly in the vicinity of Oldbridge and Jamesburg.

The Norfolk sand is extensively developed in the eastern portion of the area surveyed, particularly in the vicinity of Oldbridge, Spotswood, and Helmetta. Areas also reach out north and south along the Monmouth road between Smithburg and Prospertown.

This soil is found at all elevations, from the valley slopes of tidewater streams to the crests of some of the highest hills. It owes its distribution to the occurrence of upland deltas, ancient forelands, and the more recent terraces bordering the larger streams. In its origin it is purely sedimentary.

The Norfolk sand is a typical early truck soil. It extends along the Atlantic seaboard from New England to Alabama. In some localities it has reached a high state of cultivation and is now much more productive than the greater part of it in the area surveyed, where most of the type is still covered with a growth of shrubs and trees, chiefly pine, chestnut, and burr, basket, and chestnut oak, and their scrub variations.

The great diversity of topography of this soil gives it a wide local

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range of agricultural value and use. For instance, in the forelands south of Oldbridge and Helmetta, where the water table is close to the surface, a fair return from grain can be secured, while as developed south of Burksville, at an average elevation of 140 feet, rye would not yield on the average 10 bushels to the acre. At these higher elevations the stone fruits have a much better quality and color than where grown on lower and wetter areas.

Generally the truck grown upon the Norfolk sand is of fine quality. The soil has a special adaptation, however, for the production of sweet corn, melons, cantaloupes, sweet potatoes, asparagus, peaches, plums, and strawberries and other small fruits.

In the vicinity of Burksville and along the Monmouth road many strawberries are raised. The berries show considerable variation in quality and quantity. They are found doing their best on the black sand bordering the streams, as here they do not suffer from drought. They are not injured particularly by the heat, except where planted in clearings surrounded by woods, where there is no circulation of air to keep them from firing. Blackberries do remarkably well in such places, being able to withstand considerably more heat, while they are less profitably grown near streams, the vines having a tendency to run to wood.

The asparagus grown upon this soil type is of the finest quality. This crop is specialized in the area southeast of Hightstown. It is a better product for the market than that grown upon the Collington sandy loam, as, though not so large, the shoots grow straighter.

The production of the Kieffer pear is doing much to utilize land which would otherwise be abandoned. The fruit grown on the Norfolk sand is superior to any sold upon the New York market. It reaches its height of perfection of quality and color upon the Norfolk sand in the hilly country in the neighborhood of Perrineville and northwest toward Englishtown.

The following table gives mechanical analyses of the Norfolk sand:

Mechanical analyses of Norfolk sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7600	¾ mile N. of Oldbridge.	Fine to coarse sand, 0 to 36 inches.	0.10	4.32	26.90	29.80	33.84	1.86	2.40	0.74
7598	1 mile S. of Carr's tavern.	.....do.............	.34	2.08	7.52	28.66	41.52	15.84	1.90	2.48
7599	1 mile S. of Oldbridge.	Medium to coarse sand, 0 to 36 inches.	.82	1.48	19.00	38.18	31.24	4.78	2.58	2.60

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ALLOWAY CLAY.

The surface soil of the Alloway clay is a brown, red, or gray clay loam, with a depth of 9 inches, underlain by plastic, tenacious red, yellow, or mottled clay to a depth of 3 feet or more. Throughout the soil and over the surface is a scattering of rounded quartz or cherty gravel, varying from one-fourth to one-half inch in diameter.

The Alloway clay occurs in one extensive area southwest of New Brunswick and in smaller detached areas, usually bordering the larger streams, in all parts of the survey. Its surface is level or gently rolling, and it is found at moderate elevations. Its condition is such as to give the impression of lowness. In fact, owing to the impervious nature of the soil and subsoil of this type, and to its general position, it is usually wet and poorly drained.

The Alloway clay is sedimentary in origin, being one of the finest of the offshore deposits laid down during the marine submergence. It is not only important where it occurs typically developed, but also in the influence of its materials upon the physical characteristics of some of the other soil types of the area. This clay has been largely reworked with a portion of the Sassafras loam, and it forms the characteristic subsoil of a phase of the Collington sandy loam and the Quinton sandy loam.

The soil is cold and refractory and only partly under cultivation. The rest of the area is at present largely meadow or swamp. Under careful management the soil closely resembles the heavier limestone soils of Pennsylvania, Maryland, and Virginia.

The most desirable tilth and productiveness can only be secured by establishing a good drainage system—which ought not to be difficult, since the areas usually border the streams—and by gradually loosening the subsoil to a greater depth by use of the subsoil plow. Frequent and generous applications of lime, neutralizing the natural acidity of the soil, will do much to improve its tilth. When properly drained and cultivated this soil is most productive, being particularly well adapted to the grains and grasses.

The following table contains mechanical analyses of the Alloway clay:

Mechanical analyses of Alloway clay.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7566	Franklin Park station.	Heavy clay loam, 0 to 6 inches.	3.46	1.18	3.52	3.80	5.42	5.84	53.80	25.30
7567	Subsoil of 7566......	Heavy mottled clay, 6 to 36 inches.	1.03	.80	3.96	4.98	6.88	7.10	46.82	28.76

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QUINTON SANDY LOAM.

The Quinton sandy loam is a brown or yellow sandy loam, containing some fine gravel, with an average depth of 10 inches, grading into sticky sand and fine gravel, and underlain at a depth of from 15 to 18 inches by the same material intermingled with a considerable proportion of plastic yellow clay. The whole rests upon a bed of gravel or fine gravel and sand mixed.

This soil occurs in detached areas from the vicinity of Hightstown westward toward Trenton, and also around Princeton Junction. It occupies the ridges or the crests of hills in the areas of rolling topography.

The position and character of the Quinton sandy loam seem to indicate that it once formed ancient beaches or bars. It is clearly a sedimentary soil, and its freedom from clay or loam particles shows either that it was deposited in comparatively swift currents or else that it has been thoroughly reworked by stream or wave action. What plasticity it does possess in its subsoil, or here and there in the surface soil, is due to reworking with the material of the Alloway clay or with Sassafras loam—itself often a product of such reworking. Some areas of this soil occupy what were formerly stream deltas. Such areas are usually rather more gravelly than the typical soil, but are otherwise of about the same agricultural value.

The Quinton sandy loam has a limited distribution in the Trenton area, which gives but little opportunity to study its fertility and adaptation to crops. It is used largely for general farming, but is not so well adapted to this use as is the Sassafras loam. It is of too light a texture for grain and grass. However, corn, rye, clover, and potatoes do fairly well. This soil shows a special adaptation for growing nursery stock and all kinds of fruit. Of the fruits, the Elberta peach and Moore's Early grape are most successful, both showing a particular affinity for this type. The average yield of grapes is estimated to be 2½ tons to the acre. The yield of peaches depends on the age of the tree and the season. The quality of the fruit is said to be of the best.

The table on the following page gives mechanical analyses of the soil and subsoil of the Quinton sandy loam.

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Mechanical analyses of Quinton sandy loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7596	2 miles SE. of Lawrence Station.	Fine sandy loam, 0 to 18 inches.	1.55	2.60	11.36	10.58	25.22	22.12	18.70	9.42
7594	2½ miles SW. of Hightstown.	Medium to coarse sandy loam, 0 to 20 inches.	1.42	3.62	16.58	11.08	12.78	9.16	34.58	11.98
7597	Subsoil of 7596......	Sticky sandy loam, 18 to 36 inches.	.44	3.44	11.26	8.72	22.66	17.14	18.72	17.26
7595	Subsoil of 7594......	Sticky sand and gravel, grading into yellow clay, 20 to 36 inches.	.64	7.16	23.70	11.76	8.96	5.68	20.94	21.20

WINDSOR SAND.

This type is a coarse, gray, sandy soil containing considerable fine gravel. It occupies the hill slopes and is the result of an outcrop of the cross-bedded strata of sand and fine gravel of an ancient delta. This type is not under cultivation in this area and is covered with a growth of burr, basket, and scrub oak. It is known as the pine barrens of southern New Jersey and Maryland. In other places it is used to a limited extent for early truck and peaches.

The Windsor sand has a very limited distribution in the area, occurring only in the vicinity and southwest of Oldbridge.

ELSINBORO FINE SAND.

The Elsinboro fine sand is a yellow, reddish-brown, or brown sandy loam, with a depth of 10 inches, resting upon a subsoil much lighter in color, but of the same texture, extending to a depth of 3 feet or more. The soil contains a relatively large proportion of organic matter in areas bordering the river and streams, but this decreases as the distance from the streams increases. The great difference in color is mainly due to the variable amount of organic matter in the soil.

The Elsinboro fine sand occupies the level or gently rolling uplands, and also some of the valley slopes, below the Sassafras loam. As it occurs upon the higher levels it occasionally contains considerable gravel, while generally throughout the type there is a small quantity of this material present.

This soil is used largely for the production of early truck in the vicinity of Trenton, but with the extension of good roads its produce comes into competition with the earlier and better products of the truck lands of the Norfolk sand in Ocean County, and it is not so val-

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uable as formerly as a general market-garden soil. On the other hand, the Elsinboro fine sand is well adapted to the production of late truck, and large areas are planted in tomatoes and peas for canning purposes. This is developing into a profitable special industry on this soil.

In Pennsylvania the Elsinboro fine sand was used largely for tobacco culture, but this has been abandoned, and the areas in that part of the survey are now used for general farming. It is not as well adapted to this as the Sassafras loam.

The following table contains mechanical analyses of the soil and subsoil of the Elsinboro fine sand:

Mechanical analyses of Elsinboro fine sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7580	1 mile E. of Trenton.	Fine sand, 0 to 6 inches.	1.52	0.22	3.24	14.04	39.10	17.44	18.96	6.94
7578	2 miles E. of Tullytown, Pa.	Fine sand, 0 to 10 inches.	1.45	.56	2.40	3.02	17.24	29.34	39.36	8.08
7581	Subsoil of 7580......	Fine sand, 6 to 36 inches.	.45	.10	3.54	17.72	36.44	17.02	17.70	7.48
7579	Subsoil of 7578......	Compact fine sand, 10 to 36 inches.	.36	.20	1.74	2.14	18.86	33.48	35.10	8.48

WESTPHALIA SAND.

The Westphalia sand is a fine sand, of a loose, friable character and of variable color, having a depth of 3 feet or more. It occupies the slopes adjacent to the Norfolk sand on the forelands south of Helmetta and Oldbridge. It occupies but a small part of the area surveyed, and little or none of it is under cultivation.

The following table gives a mechanical analysis of a typical sample of this soil:

Mechanical analysis of Westphalia sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7613	2 miles SE. of Helmetta.	Fine sand, 0 to 20 inches.	0.20	0.34	3.80	18.04	62.28	11.96	1.18	2.14

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SUSQUEHANNA GRAVEL.

The Susquehanna gravel has the smallest distribution of any soil in the area surveyed. It consists of coarse sand and gravel, and is generally unproductive. It is used largely for road ballast, and is dug for this purpose from pits in the Sassafras loam or in the area northeast of New Brunswick.

PENN LOAM.

The Penn loam consists of an Indian-red, yellow, or brown loam having a depth of 10 inches and underlain by heavy loam or clay of the same color, resting upon bed rock.

This soil has a greater area than any of the other types mapped in the present survey. It occupies nearly the whole area of the consolidated formations, occurring to a large extent in the vicinity of New Brunswick, Middlebush, Metuchen, Princeton, Somerville, and Lawrenceville.

The Penn loam is derived, through the process of disintegration and decomposition, from the Triassic shales. The surface of the type is gently rolling, being slightly more uneven in the northeastern and northwestern than in the northern part of the area.

A gravelly or pebbly phase is found in the vicinity of Metuchen, southwest toward New Brunswick, Franklin Park, and Rockyhill; also west of Boundbrook. The gravel intermingled with the soil and subsoil is glacial drift material, but the quantity is not sufficient to materially affect the character of the soil. The gravelly phase, contrary to the usual experience with such soils, is thought by some to be less droughty than the typical soil.

A heavy phase, consisting of a heavy yellow clay loam, underlain by heavy clay, occurs between Princeton and Trenton. This is slightly more productive than the typical soil, especially where grain is the crop grown. It also withstands drought better, but the differences are not sufficient to form the basis of a new type.

Another heavy phase occurs adjacent to the Cecil loam on the trap ridge and on Sourland Mountain. The soil there is derived from a flagstone or argillite. It occupies the slopes of ridges. These slopes are subjected to almost continual wash, due to seepage water, while the surface is strewn with stone fragments. The soil closely resembles the Dunkirk shale loam of Chautauqua County, N. Y., and has a particular value for grape culture.

The slopes are usually much too steep and a great part of their area too thickly strewn with bowlders of the underlying trap rock to allow general farming, but are adapted to pasture, grapes, and apples.

The Penn loam, where free from stone and not too steep, is used largely for general farming, but is best adapted to grass and grain. It has a particular value for stock raising, although there is compara-

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tively little done in this industry. In some sections dairying is an important interest.

The soil is deficient in organic matter and suffers to a considerable extent from an almost imperceptible wash. The thinness of the soil is attributed to this wash, the soil material being carried away almost as fast as the soft shales disintegrate. Although generally esteemed droughty in this area, in places the soil has been found most resistant to this condition, and in such places it almost equals the limestone soils of Pennsylvania in productivity.

This tendency to drought, however, can be overcome in some degree by the incorporation of organic matter in the soil, either by the application of stable manure or by plowing under green manuring crops, and by gradually deepening the soil in plowing. If the plow is run in the fall, the shale fragments brought to the surface will be almost disintegrated by the following spring.

The following table gives mechanical analyses of the soil and subsoil of this soil type:

Mechanical analyses of Penn loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7584	3 miles SW. of Princeton.	Heavy red loam, 0 to 10 inches.	2.39	1.48	3.22	2.78	5.86	13.12	61.42	11.46
7586	1 mile NE. of Millstone.	Loam, 0 to 5 inches.	1.90	3.38	4.00	3.22	6.40	12.58	54.68	15.74
7582	1 mile E. of Flagtown.	Heavy red loam, 0 to 10 inches.	2.80	1.04	1.90	1.12	2.34	6.14	64.44	23.02
7588	1 mile W. of Middlebush.	Heavy loam, 0 to 5 inches.	1.38	3.40	7.20	4.50	7.58	5.04	41.62	29.62
7587	Subsoil of 7586......	Heavy loam, 5 to 24 inches.	1.28	3.50	5.22	3.42	6.44	12.06	53.76	15.54
7585	Subsoil of 7584......	Heavy red clay, 10 to 36 inches.	.82	.62	1.46	1.26	3.80	10.24	64.86	17.76
7583	Subsoil of 7582......	Red clay 10 to 36 inches.	1.78	.78	3.18	1.64	3.64	12.74	48.44	29.60
7589	Subsoil of 7588......	Heavy red clay, 5 to 30 inches.	1.01	2.92	7.44	4.70	8.44	5.40	36.48	34.34

PENN STONY LOAM.

The soil is a brown or yellow sandy loam 10 inches deep, underlain by a gritty yellow clay, which grades into a red clay at a depth ranging between 24 and 36 inches. Over the surface and through the soil are found considerable quantities of rounded gravel and bowlders varying from one-half to 6 inches in diameter.

The Penn stony loam is practically limited to the area occupying the

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divide northeast of New Brunswick and to the two very small areas west of Boundbrook. This soil is of a heterogeneous composition, being derived from the glacial drift reworked with the Penn loam. A variation from the type occurs along Lawrence Brook, northwest of Fresh Pond, and west of Deans. Here the soil is a sandy loam, gradually getting heavier as the depth increases.

Such crops as wheat, corn, rye, and clover are grown on the Penn stony loam, but it is best adapted to late truck, especially cabbage and tomatoes.

The following table gives mechanical analyses of the fine earth of soil and subsoil of the Penn stony loam:

Mechanical analyses of Penn stony loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7592	¾ mile E. of Piscataway.	Sandy loam containing gravel, 0 to 10 inches.	1.71	3.84	7.98	7.00	13.10	9.54	40.86	16.98
7593	Subsoil of 7592......	Sand and clay, 10 to 30 inches.	.62	2.30	7.82	7.68	13.78	9.66	36.64	21.84

CECIL LOAM.

The Cecil loam is a brown or red clay loam with a depth of 10 inches, underlain by a heavy red clay, which rests directly upon the trap rock in place. Throughout the area of this soil occur many massive bowlders, varying in size from 1 foot to 5 feet in diameter. These rocks are either diabase, gabbro, or gabbro diorite, and owe their presence to outcrops of the underlying trap rock.

The Cecil loam occupies the central portion of the trap ridge and Sourland Mountain. It owes its origin to the weathering of the rocks already mentioned. With the exception of the level uplands the surface soil of the Cecil loam is comparatively thin; on the steeper slopes there is little except the outcropping rock. Very little of this type is under cultivation. The difficulties of clearing are great, and although occupying rolling ridges the soil is wet and cold. Where cleared, the soil is producing good crops of grass, rye, buckwheat, and corn, but poor crops of wheat and potatoes, especially in years of moderate rainfall. Peaches, however, do remarkably well, having a better quality and color than any produced on the other soils of the area. Generally

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the type is adapted only to forestry or pasture. The pastures are said to be quite resistant to drought and to last a long time without reseeding.

The following table gives mechanical analyses of the soil and subsoil of this soil type:

Mechanical analyses of Cecil loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7568	¼ mile W. of Amwell	Heavy red loam, 0 to 6 inches.	3.32	1.78	3.56	1.74	4.80	7.40	63.00	17.72
7570	2 miles N. of Princeton.	Clay loam, 0 to 8 inches.	1.78	.26	1.44	1.1[illegible]	3.66	7.22	66.12	20.20
7569	Subsoil of 7568......	Gritty red clay, 6 to 36 inches.	1.91	1.46	3.20	1.9[illegible]	4.68	6.72	64.00	17.66
7571	Subsoil of 7570......	Gritty red clay, 8 to 36 inches.	.58	1.42	3.94	2.5[illegible]	6.12	7.30	49.62	29.10

PENN SANDY LOAM.

The Penn sandy loam is composed of a sandy loam, generally of a brown-red color, of medium to coarse texture, and of a depth of 3 feet or more. It occurs in the vicinity west of Boundbrook, bordering the Raritan, and north and northwest of Metuchen. Areas are also found along the Millstone River, in the neighborhood of Hillsboro, Westons Mills, and East Millstone.

The topography of this soil is that of the level to gently sloping uplands. It owes its origin to the weathering of the sandy shale of the Brunswick formation, or to an alluvial deposit of glacial origin along the rivers and within the range of their former overflow. As it occurs near the present stream courses it contains some rounded gravel, sometimes very fine and again ranging from one-quarter to one-half inch in diameter. As it is found along the Millstone River it is somewhat heavier and better adapted to general farming.

Generally the soil is too light for use as pasture or for growing grain, with the exception of rye. It is, however, particularly well adapted to early truck crops, of which early potatoes are probably the most profitable.

This soil is generally well drained, but some sections are subject to overflow in times of freshet.

The table following gives analyses of the soil and subsoil of this soil type.

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Mechanical analyses of Penn sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7591	1 mile E. of Boundbrook.	Fine to medium sandy loam, 0 to 30 inches.	0.54	1.08	8.46	16.28	38.76	10.24	17.40	7.56
7590	3 miles E. of New Brunswick.	Brown sandy loam to medium sand, 0 to 30 inches.	2.28	1.00	6.10	14.32	32.94	6.62	25.20	12.66

MEADOW.

Meadow is a term used to signify soils in a wet and poorly drained condition, irrespective of their texture or position, and it must not be confused with the prevalent usage of the word conveying the idea of grass lands. In the Trenton area the Meadow tracts generally occur along the streams. There is considerable difference in the proportion of Meadow in the several soil types. It is noticeable that along the streams traversing the Penn loam comparatively little Meadow occurs, for the reason that these streams have usually cut through the underlying rock, and their escarpments are well drained and can be readily cultivated. In the Penn sandy loam a much larger area occurs, and in favorable seasons good grass crops are secured. Next to the Penn loam the Collington sandy loam has the least Meadow, while the Norfolk sand and Sassafras loam include large areas of land in this condition.

The Meadow of the Norfolk sand has a particular value, especially where it contains thick deposits of peat—a feature characteristic of the Meadow in this soil formation—since these peat meadows are successfully used in cranberry culture.

AGRICULTURAL CONDITIONS.

Throughout the area the farmers follow a system of mixed agriculture, although the boundaries of each soil type limit crop specialization more or less definitely. The system shows a somewhat advanced stage in the adaptation of soils to crops.

The degree of prosperity varies in different parts of the area. Taking the character of the farm buildings and the general condition of the farms as a basis, the most prosperous communities are found upon the Penn loam of the consolidated area and the Sassafras loam of the Coastal Plain formation. For agricultural purposes the Penn loam is worth from $25 to $60 an acre; the Sassafras loam from $20 to $150, the

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differences in price in each case being dependent mainly upon location with respect to market and transportation facilities. The farm buildings usually consist of a large and comfortable dwelling and one or more commodious barns for hay and stock. In the northeastern and northwestern parts of the area many farms have been bought by wealthy business men of New York and neighboring cities for summer homes, and many costly residences have been built. The farms are improved with neatly trimmed hedges or patent wire fences.

As the distance from the area of the consolidated formations increases as one passes through the Coastal Plain, the buildings gradually become poorer and general conditions less prosperous. But little hay and grain are grown on the lighter soils of this region and consequently large barns are not needed. In the middle south and southwest the state of the agricultural classes again becomes much better. This area includes Creamridge, a part of the country noted in this section for its fine buildings and thriving farms. Over 50 per cent of the area surveyed is heavily encumbered by mortgages.

Where farms are rented the system of tenure is variable, but farms in the Coastal Plain are generally worked on shares, while in the consolidated area a money rent is customarily asked. The farms are of all sizes, from 5 up to 1,000 acres.

Considerable difficulty is experienced in securing good, reliable help. The area surveyed includes within its boundaries the cities of Trenton and New Brunswick, and lies close to Philadelphia and New York, and the labor, therefore, is apt to be made up largely of transients. An intelligent man can generally command a higher wage, in employment requiring fewer hours, in the city than he can secure on the farm.

In considering the character of the products upon which the agriculture of the area is based, and in pointing out the relation of these products to the several soils, it seems necessary to emphasize by repetition some of the more important facts already dwelt upon in previous chapters of this report.

There are fifteen different soils in the area. These include soils resulting from the disintegration and decomposition of the consolidated formations, and from the weathering of the later Pleistocene sediments of the Coastal Plain.

In the former area the Penn loam has the largest distribution, occupying nearly the whole area of the northern part. It is largely used for general farming, but is best adapted to grass and grain. With the exception of a few areas where the soil is deeper it is generally considered too droughty for the best results. But this is not an irremediable condition of the soil, being rather the result of imperfect methods of management. The soil is generally deficient in organic matter and is subject to an almost imperceptible wash. In the depres-

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sions where organic matter and a deeper soil have accumulated the soil maintains a good supply of moisture, and crops are carried through dry periods as well as upon any other soil in the area. If, in place of the shallow culture generally practiced at present, there should be a gradual deepening of the soil, by deeper plowing, and the incorporation of organic matter, the natural conditions would be materially improved. It is an excellent grass land and admirably adapted to raising stock. In some sections dairying is also an important interest on this type.

The Cecil loam, owing to location, is generally adapted only for hill pastures and forestry. In some places, particularly on Sourland Mountain, areas of this soil offer good opportunities for raising sheep. The pastures produce an excellent quality of grass and are remarkably persistent. For agricultural purposes this land is worth from $12 to $35 an acre. The farm buildings are usually inexpensive and not in the best of repair. The fences are usually made of the bowlders collected from the fields. The Cecil loam, however, has a particular value as a peach soil. In no other section of the area surveyed can the peaches compare with the mountain peaches in color and quality. The trees bear abundantly, but there is room in many orchards for the introduction of better methods of culture.

The Penn sandy loam is adapted to light farming and the production of truck, for which purposes it is largely used.

The Penn stony loam is used largely for general farming, but it is better adapted to light farming and late truck. It is somewhat difficult to work, owing to the large percentage of large and small rounded gravel scattered through the soil. It is well drained, but not droughty, and is highly esteemed for its production of late truck and fruit.

Of the sedimentary soils of the Coastal Plain, the Sassafras loam has the largest extent. This type is used for general farming and is well adapted to this purpose. It has an especial value as a soil adapted to dairy farming and to the production of apples. The yield of hay does not average so high as on the Penn loam, but the Sassafras loam makes excellent grazing land. The meadow pastures are good and last a long time. With this soil, even more than with the Penn loam, deeper plowing should be practiced. In some places there is need of drainage, which in most instances can easily be had by ditching to the underlying gravel bed, found usually between 1 and 3 feet below the surface.

In order of extent the Collington sandy loam comes next to the Sassafras loam. This type is especially adapted to the production of corn, rye, and potatoes. The corn produced on this type is superior to any other grown in the area, and the rye can not be equaled for length of straw and yield of grain, although it is closely approached by that produced on the Sassafras gravelly loam or on the Quinton sandy

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loam. The production of potatoes on the Collington sandy loam is gradually developing into a special industry. The yield is heavy and the product of fine quality. The hilly country on the drainage divide of the southeastern part of the area is largely covered by the Sassafras loam, and the soil there has shown a marked adaptation to the Kieffer pear, while the general features of soil, climate, and topography of this section would seem to indicate ideal conditions for grape culture. The Kieffer pear, although of fine quality as grown upon the hilly areas of this soil type, is not as good as that produced on the Norfolk sand, especially those areas of Norfolk sand occupying the highest elevations. Generally the pear trees grown upon the Collington sandy loam have a tendency to run to wood, and the fruit is not highly colored. On the higher areas of the Collington sandy loam the fruit, although not so large as when grown at lower levels, is of better quality and color. On the lower areas the fruit generally rusts.

The Norfolk sand occurs in the eastern and southeastern parts of the area mapped and is found at all elevations. It is a typical early truck soil, but owing to the proximity of the underlying water table, or in other cases to elevation, its adaptation is somewhat modified. In the areas having a high water table it is capable of producing fair crops of grain, clover, tomatoes, and cabbage. Where the ground water is lower it yields the best quality of early truck, such crops as sweet corn, melons, cantaloupes, asparagus, and all kinds of stone and cane fruits being most profitably grown. Comparatively little of this soil is under cultivation, the greater part being covered with a forest of pine and burr, basket, and scrub oak.

The Elsinboro fine sand is not nearly so early as the Norfolk sand and is better adapted to late truck. It produces good crops of corn, tomatoes, cabbage, asparagus, and potatoes, the best of which are of better quality than those grown upon the Collington sandy loam, though the yields are much lighter. The areas of this type occurring in Pennsylvania, along the Delaware River, are at present largely used for dairy farming. Formerly they were used quite generally for tobacco culture. This crop has now been practically abandoned, as it was found impossible to compete with the Connecticut Valley growers. The soil is adapted to a wrapper leaf. At one time this tobacco was sold almost entirely for export to Germany, but since the change in the tariff there it has not been raised to any extent.

Comparatively little of the Alloway clay is under cultivation. It is a cold and wet soil, but with thorough drainage is most productive and well adapted to grain and grass.

The Quinton sandy loam is especially adapted to such crops as rye, corn, clover, and potatoes, although not so well adapted to these as is the Collington sandy loam. It has shown, however, that it is a very useful soil for growing the Elberta peach and Moore's Early grape

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and for nursery stock generally. The yield of grapes is estimated to average 2½ tons to the acre.

The Sassafras gravelly loam has only a limited distribution within the area surveyed. It would have the same value as the Susquehanna gravel had it not been reworked with the Alloway clay or the silt of the Sassafras loam. As it is, it yields fine crops of rye, clover, and potatoes and is especially well adapted to peaches and other stone fruits.

The Windsor sand is not under cultivation, while the Westphalia sand is cultivated to a very limited extent. The Susquehanna gravel has the smallest area of any of the soil types in the present survey. It is one of the most unproductive of soils. The gravel of this formation is used for road ballast.

Much of the area classed as Meadow could readily be reclaimed by underdrainage. Lands now used only for pasture, and for this only a part of the year, could at small cost be converted into grass lands of great productiveness and permanency. Drainage tiles should be used for this purpose. Tiles are manufactured in large quantities from the various clay deposits underlying the different soil formations and are comparatively cheap. On the Meadow cranberry culture forms a very important and growing industry. The New Jersey cranberries find their way into all the important markets of the United States and Canada.

Commercial fertilizers are very generally used on the soils of this area. Great quantities of stable manure are brought into the area from New York and other near-by cities. This manure is used in the southern part of the area, especially in the growing of truck. The use of city manure is said to be gradually decreasing. It is usually heavily watered in the cars and is apt to be damaged by too rapid fermentation. It is also disliked because it contains so many weed seeds. Lime is generally applied to the soil in varying amounts and at intervals of about five years. Its use is thought to be very necessary, especially upon the Alloway clay, the Penn loam, and the Sassafras loam, where, besides neutralizing the acidity, it gives a better tilth. The applications can not be generally heavy enough, as over 70 per cent of a large number of determinations show the soils to be acid. Formerly large quantities of greensand marl were used, but now, except in the immediate neighborhood of some of the richer deposits, this natural fertilizer is but little employed.

The area surveyed is traversed by the New York, Amboy and Pemberton divisions of the Pennsylvania Railroad system, the Central Railroad of New Jersey, and the Philadelphia and Reading Railroad. These roads afford ready and rapid transportation to the neighboring markets.

The country roads are fairly good. The better roads are being gradually extended out from the larger towns, and some already reach

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considerable distances back into the country. Consequently a great deal more carting is done than in most areas, 25 miles not being an unusual distance for wagon transportation of even the more perishable products. From the sandy area of Ocean County early truck is hauled in wagons to Trenton. This has seriously affected the growers of truck in the neighborhood of Trenton, who use the Elsinboro fine sand, a later soil, for truck growing. The principal markets for the products of the area surveyed are New York, Trenton, and Philadelphia. With the great diversity of soils, each having its special value for certain staple crops, the proximity to the important markets, and the exceptionally good facilities for transportation, this ought to be one of the most productive and prosperous areas of the Atlantic seaboard.

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SOIL SURVEY OF THE ALBEMARLE AREA, VIRGINIA.

By CHARLES N. MOONEY and F. E. BONSTEEL.

LOCATION AND BOUNDARIES OF THE AREA.

The Albemarle area is situated a little to the northwest of the geographical center of the State. It lies between 78° 30′ and 79° west longitude and 37° 45′ and 38° 30′ north latitude. The area is rectangular in shape, and is 52 miles long north and south by 27 miles wide east and west, comprising an area of 1,404 square miles or 898,560 acres. This includes all of the Harrisonburg sheet and the northern half of the Buckingham sheet of the U. S. Geological Survey. (See fig. 4.)

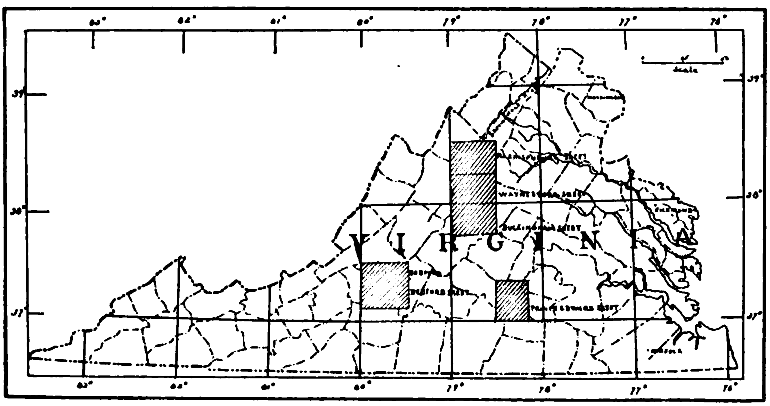

FIG. 4—Sketch map showing areas surveyed in Virginia.

For convenience in the publication of the soil map the area has been divided into three sheets, which are called, from north to south, the Harrisonburg, Waynesboro, and Buckingham sheets, respectively. These cover portions of seven counties. Albemarle County comprises about one-third of the area; Buckingham, Greene, and Page counties represent about 80 square miles together, and the remaining area is about equally divided between Nelson, Augusta, and Rockingham counties.

The area is entirely an agricultural one, and as such it has become important. The valley has long been known as a grain, grass, and stock raising section, while the Piedmont has, until the last few years,

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been important as a tobacco-growing section. Within the last half century Albemarle and Nelson counties have become widely known because of the fine quality of apples and peaches produced on the soils of the eastern slope and foothills of the Blue Ridge Mountains included within their boundaries. They are often spoken of as the home of the Albemarle pippin. At present great interest is being taken in the development of the fruit interests, and therefore it has been one of the objects of this survey to study the soils in their relation to the growing of fruits.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Before the expedition of Governor Spottswood this section had never been traversed by white men. Only vague ideas of the country had been gained from the Indians. In 1716 Governor Spottswood and his followers traveled westward until they came to the top of the Blue Ridge Mountain at Swift Run Gap, which is within the Albemarle area. From there he saw the great Valley of Virginia, which he described as a rolling prairie covered with a luxuriant growth of tall grasses and the feeding ground of herds of buffalo, deer, and other wild animals. The wonderful tales he told of the country spread through the older settlements and on the Continent. Ten years later, or about 1726, a settlement is supposed to have been made at Elkton by Germans who had followed Spottswood. From this time on the settlement of the country was gradually extended. Two tides of immigration set in toward this part of Virginia; one came up the valley from Pennsylvania, and consisted of Germans and later of Scotch-Irish from Pennsylvania and Ireland. The latter, natives of the north of Ireland, were Presbyterians and refugees from the religious troubles in the home country.

The Germans are said to have taken up the lower lands, while the Scotch-Irish selected the higher-lying tracts. All these settlers were industrious and thrifty, engaging in stock raising and the production of the simpler necessaries of life. Wheat was introduced at an early date, and has since continued to be the staple crop of the valley.

Soon after the beginning of settlement of the valley forests began to grow up, first along the stream courses and finally covering the ridges spreading from the mountains on each side of the valley. The forests were principally composed of hard-wood trees, except on the sandy ridges, where they were of pine.

The valley being remote from the scenes of active operations of the war, the domestic life was during the Revolution generally undisturbed. Some of these settlers, and especially the Germans, were averse to slavery, and consequently cultivated their farms themselves. Some, the Scotch-Irish, and especially those living in the northern part of

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the area, owned slaves. The institution, however, was never very popular, and as early as 1832 an effort was made toward its abolishment.

During the civil war this section was devastated, but at its close the people, who had always been used to work, returned to their farms and began to build them up again. This portion of the valley has completely recovered, and is now, as before, one of the most fertile and prosperous agricultural sections of the country.

The eastern slope of the Blue Ridge was first settled in 1734 by Irish immigrants who came up the valley and crossed by Woods Gap (now known as Jarmans Gap). (See Pl. V.)

The other tide of immigration came from the older eastern settlements in the State. The rage for speculation hastened the occupation of this country, the laws allotting certain quantities of land to each person coming into the territory. At first large grants—generally several thousand acres in extent—were obtained by wealthy men for the purpose of speculation. Few of these ever occupied their lands, but either gave them into the charge of tenants or placed their own servants upon them to make clearings and enter upon the cultivation which was required by law to perfect their titles. Soon, however, smaller grants were made to persons who came to live permanently in the country. The people first settled along the courses of the James, Ravanna, and Hardware rivers. By 1785 all sections of the country were more or less occupied.

Tobacco soon became the staple crop and was grown year after year upon the same land. When the land became exhausted, new land was cleared and the old fields were thrown out of cultivation and allowed to wash and become reforested. The cultivation of tobacco was profitable because of the large number of slaves kept. The plantations being large, each one formed practically an independent community, producing all the food and clothing for the owner's household and the slaves. Flax and cotton were grown, spun, woven, and made into clothing. Neither of these products, however, ever became a commodity for sale.

The market in the early days was at Richmond. The transportation was mostly by boats down the Ravanna and Hardware rivers to the James, and thence to Richmond. These trips were generally made in flat boats at times of high water. Transportation was greatly facilitated in 1841, when the James River Canal was completed and canal boats ran from Richmond as far up the river as Lynchburg. Not only did this canal afford an outlet for products east of the Blue Ridge Mountains, but also for the valley, and in consequence good roads were built from the valley across the mountains to places along the canal. Scottsville, which is just outside of the area but in Albemarle County, became an important shipping point.

Just before the civil war the Chesapeake and Ohio Railroad was

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completed across the Blue Ridge Mountains into the valley, and in the seventies the canal was abandoned and a railroad laid on its towpath.

As a result of the civil war the Piedmont section received a check from which it is only now beginning to recover. The land thrown out of cultivation because of lack of capital and labor became badly washed, so that much of it was practically worthless for cultivation. The development of the fruit industry has brought this section into prominence again, and generally the people are becoming prosperous.

CLIMATE.

The following tables, taken from the records of the Weather Bureau, give the normal monthly and annual temperature and rainfall, and the occurrence of latest spring and earliest fall killing frosts:

Normal monthly and annual temperature and precipitation.

Month.	Buckingham.		Charlottesville.		Staunton.		Dale Enterprise.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	*Inches.*	*°F.*	*Inches.*	*°F.*	*Inches.*	*°F.*	*Inches.*
January	33.8	3.31	36.4	3.49	33.9	2.63	31.9	2.68
February	33.0	3.38	34.6	3.59	34.5	3.16	34.8	3.26
March	44.3	4.11	46.3	3.49	44.3	3.06	40.8	3.25
April	54.0	2.60	56.6	2.43	53.8	2.36	52.9	3.04
May	65.0	3.36	67.0	4.33	64.2	4.32	63.0	5.40
June	73.3	2.89	74.5	3.02	71.4	3.78	71.5	4.90
July	76.8	3.87	77.1	5.53	74.9	3.28	75.1	4.29
August	75.5	3.27	76.1	6.56	74.8	3.56	73.5	3.77
September	70.0	3.83	65.3	2.39	69.1	3.74	68.7	3.95
October	57.4	3.58	57.0	4.13	56.4	4.26	56.2	2.96
November	46.9	2.52	48.9	1.92	46.7	2.22	45.7	2.39
December	36.7	2.24	39.4	2.87	38.2	2.05	38.2	2.30
Year	55.6	38.96	56.6	43.75	55.2	38.42	54.6	42.19

First, last, and average dates of killing frost.

Station.	Last in spring.	First in fall.	Average for spring.	Average for fall.
Buckingham	Apr. 9	Sept. 23	Apr. 17	Oct. 15
Charlottesville	Apr. 24	Oct. 9	Apr. 5	Nov. 4
Staunton	May 22	Sept. 29	Apr. 22	Oct. 20
Dale Enterprise	May 17	Sept. 24	Apr. 17	Oct. 10

Two of these stations, Charlottesville and Buckingham, are given for the Piedmont section, while Dale Enterprise and Staunton represent the valley. Buckingham and Staunton do not lie within the area, but are close enough to give reliable data for their respective sections. No data were obtainable for the mountains or the immediate foothills. This is unfortunate, as the fruit interests are most important in these parts of the area.

That there are climatic differences in these different sections is generally recognized. There is an especially wide range in the approach

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of spring and the lateness and earliness of frost. The Piedmont section, having a lower altitude and being sheltered from the cold winds from the west and northwest by the Blue Ridge Mountains, has a milder climate than the valley. The extreme difference in time of the ripening and the harvesting of the crops in the different sections is about two weeks, the Piedmont section being that much earlier than the mountain section, while the valley comes in between. This has an important bearing, especially as regards fruit-growing. The lower Piedmont is best for early varieties, while the mountain and valley sections are best for winter apples.

There is also about two weeks difference between the dates of late and early killing frosts in the valley and in the Piedmont sections. On the eastern slope and foothills of the Blue Ridge, and on the detached ranges of the Piedmont, there is what is called a frostless belt—a zone at certain altitudes where vegetation is retarded in the spring until all danger of killing frosts has passed. The lower limit of this belt is at an elevation of from 900 to 1,000 feet above sea level. The freedom from frost at the time of bloom is a great factor in the successful growing of fruit, and consequently many orchards are planted in this belt.

Elevations above 2,000 feet are, on the contrary, subject to sleet and hail storms and heavy snows, which do much damage to trees. Because of cold winds the western slope of the Blue Ridge is not adapted to fruit-growing, nor is it as good for cultivated crops or grasses, because of the unfavorable climatic conditions.

The rainfall over the whole area is uniformly distributed throughout the year. It is generally sufficient during the growing season to prevent injurious droughts. Frequently the rains are heavy and consequently much damage is done the lands by washing, especially in the Piedmont section.

PHYSIOGRAPHY AND GEOLOGY.

The Albemarle area embraces portions of three important physiographic divisions: The Piedmont Plateau, Blue Ridge Mountains, and the Great Valley of Virginia.

The Piedmont Plateau occupies the east and southeast parts of the area, and includes parts of Nelson, Buckingham, Albemarle, and Greene counties. It presents the usual surface features of the Piedmont region, characterized by a broad, plainlike surface, with rolling hills, cut by numerous small stream courses flowing in narrow, winding valleys in a general easterly direction.

Drainage has long been established in this division. The James River, the Ravanna, and the Hardware rivers constitute the principal drainage systems in this section.

The rocks consist of coarse-grained granite, gneiss, and schist of Pre-Cambrian age, cut by dikes of diabase and diorite, with numerous

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quartz veins through all. In the southeastern part of the area surveyed occurs a broad belt of the Newark formation, consisting of a red and gray sandstone, various colored shales, and coarse, basal conglomerates. These are Jura-Trias in age and have much intrusive diabase. On account of the large proportion of feldspar which it contains, the granite decays readily and the resulting soils are deep.

In many cases decomposition has extended to great depths, but the rock still retains its form, crumbling on exposure. The gneisses, schists, and shales, because of their structure, are also deeply weathered. The diabase and diorite are found in a comparatively fresh condition at slight depths, while the sandstones, being more resistant to erosion, usually form ridges.

The general direction of these formations is northeast and southwest. They are cut across by the larger streams, while the smaller streams more often have a parallel direction, frequently along the boundary of two formations.

In elevation this division ranges from 300 feet above tide level in the east to between 1,000 and 2,000 feet on some of the spurs and foothills of the Blue Ridge on the west.

In the Piedmont section, between the Blue Ridge Mountains and the Southwest Range, lies a double range of small mountains, known collectively as the Ragged Mountains, because of their ragged appearance. These begin as a series of low hills on the Waynesboro sheet near Charlottesville and extend southwest through the area, barely reaching a maximum height of 2,500 feet above sea level. They are composed of granites, varying much in composition, and have weathered so unequally that sharp peaks and ridges have been formed, with numerous V-shaped coves on the slopes.

The Blue Ridge Mountain system extends throughout the area surveyed in a northeast and southwest direction, reaching a maximum elevation of a little more than 3,900 feet. It is characterized by its broad, smooth ridge, composed of schist of Algonkian age, flanked on the eastern slope by spurs and sharp knobs of granite and on the western slope by narrow, ragged ridges and sharp foothills of sandstone and low, rounded knobs and gentle slopes of shale of the Cambrian period.

The Blue Ridge marks the western boundary of an ancient continent and forms a natural divide which is drained by small, rapid streams flowing into the Shenandoah River on the west and into the Ravanna, Rockfish, and James rivers on the east. On account of the great variety of rocks represented, a corresponding variety of soils is found, ranging from the deep loams and clay loams derived from the schist to a mass of bowlders and fragments of sandstone almost devoid of soil covering.

The main ridge consists for the most part of a series of schists rich in epidote and other potash-bearing minerals, to which the fertility of

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the resulting soils has been ascribed. Weathering in these has been rapid and the soils are deep and mellow.

The sandstones vary in character from quartzite through fine-grained to moderately coarse conglomerate. All are very siliceous and resist weathering, and soil covering is either wanting or is necessarily poor and thin.

The shales vary from argillaceous to sandy and are marked by transition beds of sandstone in the shale and shale in the sandstone. From their character weathering has been greater in the shales than in the sandstones.

The Great Valley of Virginia occupies the remainder of the area, extending from the Blue Ridge to the Allegheny Mountains. It ranges in elevation from 1,200 feet above tide level to over 1,700 feet on some of the higher hills and ridges, about 1,300 feet being the general average. It includes parts of Rockingham, Augusta, and Page counties in the area surveyed, and is drained by the Shenandoah, North, South, and Middle rivers and their tributaries. In the northern part the valley is divided by Massanutten Mountain into two valleys, known as the Page and Rockingham valleys, respectively.

In general it is a broad, gently rolling valley composed of blue and gray limestones and dolomites of the Silurian and Cambrian periods. The soil derived from the pure limestones is a red clay of good depth and great fertility, while those derived from the harder, impure gray limestones are more shallow and usually lighter in color. On some of the lower ridges of the valley a schistose structure has been developed in the limestones, which are locally termed "slaty ridges." The soil on these is usually a heavy clay of yellowish color, mixed with slaty fragments and resting on a mass of broken rock at slight depth. Many of the higher ridges and knobs consist of cherty limestone, and on account of the angular fragments on the surface and in the soil are known as "gravel lands." A few of the higher ridges and hills are capped by thin beds of sandstone, which by disintegration have covered the slopes to a varying depth with sand.

Sink holes are numerous in all varieties of the limestone, and render cultivation difficult. Many beautiful limestone caverns form an attractive natural feature of the valley.

Massanutten Mountain is a long, narrow ridge of massive white sandstone of Silurian period, rising in steep cliffs to an elevation of from 2,500 to 3,300 feet and almost lacking in soil covering. Surrounding its base and extending southwest throughout the valley portion of the area a broad belt of shale occurs. It is also of Silurian age. Near the mountain this formation is in some places so deeply covered by sand and bowlders of sandstone as to have little influence on the soil, but in the large area from Montevideo through Fishersville it is well developed. Its very characteristic topography consists of small

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hills of equal elevation, smooth contour, and fairly steep slopes, well drained by many small streams.

This is a uniform brown or yellow argillaceous shale, with occasional admixtures of sand. The lower beds, exposed in a few small areas, are calcareous and carbonaceous, the latter having a characteristic black color. This shale is deeply weathered and crumbles readily on exposure. The soil is a yellow clay containing a high percentage of shale fragments and resting on a mass of broken rock at varying depth. The roads in this formation are good and are easily kept in repair.

Economically the limestone furnishes an unfailing source of lime for agricultural and building purposes, and of metal for the construction of roads. There are many good macadam roads in this section of the valley, mostly owned by private corporations and on which toll is collected.

A narrow belt of soapstone, appearing near Alberene, Albemarle County, and extending southwest throughout the area, furnishes a stone extensively quarried and manufactured into various articles of general use.

SOILS.

Owing to the wide range of geological formations found in the three distinct physiographic divisions of the Albemarle area, an unusually large number of soil types were found in this survey. In all, eighteen types are shown on the maps accompanying this report. The names and actual and relative areas of these types are given in tabular form below:

Areas of different soils.

Soil.	Harrisonburg sheet.	Waynesboro sheet.	Buckingham sheet.	Total area.	Proportional extent.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Per cent.*
Edgemont stony loam	75,136	50,048	9,472	134,656	14.9
Porters sand	12,800	25,472	76,864	115,136	12.6
Cecil loam		39,104	55,488	94,592	10.5
Cecil clay	1,344	24,704	53,632	79,680	8.8
Hagerstown shale loam	31,296	23,936	20,096	75,328	8.3
Porters black loam	18,112	21,888	28,736	68,736	7.6
Hagerstown stony loam	47,552	11,584		59,136	6.5
Cecil sandy loam	2,944	38,912	5,952	47,808	5.2
Hagerstown sandy loam	35,520	9,984		45,504	5.0
Meadow	12,992	15,872	11,776	40,640	4.5
Porters clay	10,944	16,000	5,568	32,512	3.6
Hagerstown loam	11,776	19,008		30,784	3.4
Hagerstown clay	25,920			25,920	2.9
Conestoga clay	12,224	4,736		16,960	1.9
Penn clay			16,128	16,128	1.8
Conowingo barrens			6,976	6,976	.8
Conowingo clay			6,272	6,272	.7
Penn sandy loam			5,568	5,568	.6
Total	298,560	301,248	302,528	902,336	

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HAGERSTOWN CLAY.

The soil of the Hagerstown clay is a heavy dark brown to dark reddish brown loam or clay loam, with a depth ranging from 6 to 12 inches and averaging about 8 inches. The subsoil is a sticky, dark-red clay loam, grading quickly into stiff, tenacious clay. In the lower situations the soil is a deeper loam and the subsoil has a yellowish-red color, generally becoming redder as the depth increases, but in texture is not much different from that of the ridges.

This soil type occurs in one large, irregular-shaped, but connected area in the northern part of the valley, with a few small areas occurring just southwest of Massanutten Mountain, between Taylors Springs and Mount Crawford.

The surface features partake of those of the valley. The central part in the vicinity of Harrisonburg is low and rolling, while to the east and west rise ridges about 300 feet higher than the elevation at Harrisonburg.

The rolling character of this formation affords excellent surface and underdrainage.

This soil is of residual origin, derived from the weathering of pure massive limestone. The weathering, which has gone on to a great depth, has been one of solution in the rain waters falling upon it. The solubility of this limestone in acids has been found to be approximately 95 per cent, this representing the actual lime carbonate which is readily soluble in soil water. The insoluble residue of 5 per cent of the rock thus represents the resultant soil. This solubility varies greatly locally, as is evidenced by the numerous sink holes and the many caverns which occur in the formation.

Generally the surface is free from stones and bowlders, although occasionally they occur in the subsoil. Outcrops of the parent rock, however, are found at the foot of some of the ridges to the west and north of Harrisonburg, while most of the northern part of Chestnut Ridge, included in the area, is stony. These rock outcrops occur mostly in parallel lines, with intervals of soil between. As a rule, these rock areas are not tillable for a cultivated crop, but make the very best of grazing land. The soil is loamy and exceedingly fertile, and blue grass grows luxuriantly upon it. Crops of wheat have been grown on some of the areas, giving a rate of yield per acre as high as the stone-free areas, even though one-half or more of the surface was occupied by rocks. These rocky areas do not lower the value of the farms. They bring a high price for pasture lands.

Of the valley soils the Hagerstown clay is the most generally desired. It is very fertile and produces large crops. It is best adapted to wheat and grass, and these are the principal crops produced. Wheat yields on an average about 25 bushels per acre, although much larger yields are often obtained. The land is of a too heavy texture for corn, and

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little is grown, except in some of the lower areas, where the soil is more loamy and deeper, and then good crops are produced. Large quantities of timothy and clover hay are made, much of it being sold from the farm.

The land is somewhat difficult to work on account of its heavy nature. Its tilth is generally improved by fall plowing, exposing the soil to freezing and thawing and to the winter rains. Little commercial fertilizer is used, the farmer depending mostly upon turning under sod and barnyard manure. Lime is beneficial. The owners are prosperous, as shown by the condition of their farms, which are well tilled and well fenced, and by pretentious dwellings and large barns and outbuildings, all of which are painted and kept in repair.

The farms are large, averaging more than 200 acres. The value of the land ranges from $75 to $100, and even more, per acre. The high prices are due to the nearness of Harrisonburg, a thriving town, and to the good macadam roads and railroad facilities.

The following table gives mechanical analyses of soil and subsoil of this type:

Mechanical analyses of Hagerstown clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7197	¾ mile E. of Harrisonburg.	Reddish-brown loam or clay loam, 0 to 8 inches.	2.28	2.02	2.08	1.20	3.38	4.64	67.10	18.96
7199	2 miles NE. of Harrisonburg.	Light-brown clay loam, 0 to 10 inches.	1.62	.46	3.02	2.70	2.66	1.40	57.00	32.76
7201	1¼ miles S. of Dale Enterprise.	Reddish-brown clay loam, 0 to 8 inches.	2.33	1.70	2.70	2.14	4.74	10.14	43.58	34.66
7198	Subsoil of 7197......	Dark-red clay, 8 to 36 inches.	.52	.44	1.12	.96	3.38	2.70	36.42	54.82
7200	Subsoil of 7199......	Brown sticky clay, 10 to 36 inches.	.72	.10	.98	.64	1.16	2.64	28.56	66.08
7202	Subsoil of 7201......	Dark-red stiff clay, 8 to 36 inches.	.46	.64	.64	.50	1.46	4.28	24.46	68.02

HAGERSTOWN LOAM.

The Hagerstown loam is a light to dark brown or reddish-brown heavy loam from 4 to 15 inches in depth, averaging about 10 inches. The subsoil grades from a yellowish-red or red clay loam into a stiff, tenacious red clay.

In the vicinity of Stonewall much of this formation has a dark rusty-red color, due probably to the large iron content. In the vicinity of

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Waynesboro the soil contains a large amount of fine sand, even approaching a sandy loam.

This type is known locally as "loose limestone land," in contrast to the Hagerstown clay, which is known as "heavy red clay land." Many rock outcrops occur on the ridges.

This soil occurs in the valley part of the Harrisonburg and Waynesboro sheets. There are two principal bodies, one in the vicinity of Stonewall and the other just west of Waynesboro. Other smaller areas occur throughout the valley, along the slopes of streams tributary to the Shenandoah River.

The area in the vicinity of Waynesboro is gently rolling, sloping slightly toward South River, and is drained by many small streams flowing into South River. The topography of the area near Stonewall is similar to that of Hagerstown clay, consisting of a series of high, rolling ridges, but with steeper slopes, which are badly washed. A tendency to wash is a property of this soil distinguishing it from the Hagerstown clay, which rarely washes.

Like the Hagerstown clay, this soil has been derived from limestone, and by the same process of weathering, but the limestone itself is different, being a fine, gray crystalline variety that is much harder and less pure. A fine-grained, shaly sandstone also enters into the formation of this soil in places.

Many sink holes, as well as caverns, occur in the areas of this soil type. The largest caves in this and other areas occur in this variety of limestone.

The Hagerstown loam is much easier to cultivate than the Hagerstown clay, and is much better adapted to general farming. Wheat is sown upon it year in and year out, and the best improved farms will average nearly as large crops as are secured from the Hagerstown clay, but in general the average is from 5 to 10 bushels less per acre. The yield of corn is much larger, the average being from 40 to 50 bushels per acre. It is preeminently the corn soil of the area. It is not as strong grass land as the heavier soils, yet it affords a fine natural bluegrass pasture. Besides the general farm crops this soil produces fine winter apples, the York Imperial, Winesap, Ben Davis, and Baldwin being the varieties chiefly grown. Several large orchards are found upon this soil. The more gravelly phase of the soil is better suited for fruit growing. The York Imperial is probably the variety for which it is best adapted. This variety produces large crops, and the fruit is of good color, flavor, and keeping quality. It is the variety mostly planted and can be depended upon to bring profitable returns every season, where the orchard is properly cultivated and sprayed.

The value of the Hagerstown loam is not as high as the heavier valley soils. The average price per acre is about $50, but the best

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improved sells as high as $85, and when planted to orchard, as high as $200 per acre. This land, like most of the valley lands, is not on the market.

Analyses of typical samples of the soil and subsoil of this type are shown in the following table:

Mechanical analyses of Hagerstown loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7203	4 miles W. of Waynesboro.	Light-brown fine loam, with sand, 0 to 10 inches.	2.34	2.74	1.78	1.40	3.24	15.74	52.80	21.98
7205	1 mile W. of Waynesboro.	Light-brown loam, with fine sand, 0 to 8 inches.	2.22	2.84	3.60	2.44	7.12	15.20	43.84	24.74
7207	1 mile NW. of Mount Sidney.	Light-brown loam, 0 to 10 inches.	1.52	4.96	3.40	1.90	4.14	13.08	46.24	25.94
7208	Subsoil of 7207......	Clay loam to clay, 10 to 36 inches.	.46	.98	1.50	1.00	2.44	8.76	39.28	45.14
7206	Subsoil of 7205......	Brown clay loam to clay, 8 to 36 inches.	.70	.84	1.98	1.54	4.18	11.02	32.92	47.24
7204	Subsoil of 7203......	Brown clay to stiff red clay, 10 to 36 inches.	.79	.44	.74	1.08	1.74	9.34	34.58	52.24

HAGERSTOWN STONY LOAM.

The soil of the Hagerstown stony loam is a fine sandy loam to silty loam, with an average depth of 8 inches. The color of the soil is usually brown, but varies sometimes from light gray to yellow. The subsoil generally grades from a yellowish or yellowish-red clay loam into stiff red clay. The clay is reached usually at depths less than 36 inches, the average being about 24 inches. Upon the surface and in the soil there are angular fragments of cherty material. The quantity varies greatly. On the tops and steeper slopes of many of the ridges the formation is nothing more than a mass of these fragments with some fine sandy loam in the interstices, while on the lower and gentler slopes the proportion of fragments decreases, the soil becoming quite loamy and darker in color. In such localities the chert content is as low as 10 per cent of the soil, while in the subsoil there is practically no chert, or at most only a little in the upper few inches.

These fragments are composed of massive, crystalline, and cherty limestone, varying in size from a fraction of an inch to 8 inches in diameter, but with an average size of from 2 to 3 inches. Very often the larger stones have been removed. These fragments are locally called gravel and the land is known as "gravel land."

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The Hagerstown stony loam occurs in the valley part of the area, in the Harrisonburg and Waynesboro sheets. There are three principal areas. These areas as a rule are continuous, though they become somewhat broken at their southern extremities. The area extending north from Bridgewater occupies the series of hills and ridges around Mile Hill and Mount Clinton. The largest area occupies Chestnut Ridge and near-by ridges, while the third area covers the second series of ridges west of the Shenandoah River and its South Fork from McGaheysville southward. Small areas occur near these larger areas.

The Hagerstown stony loam occupies the higher and steeper ridges of the valley. These ridges often culminate in round, sharp-pointed hills about 300 feet higher than the general level of country. On account of its physiographic position and the stony nature of the formation the natural drainage is good.

This soil has been derived from the weathering of impure or cherty limestone, and the chert fragments in the soil and subsoil represent the less soluble parts of the rock, which have resisted weathering.

Wheat and corn are the chief crops grown upon the Hagerstown stony loam. Wheat yields on the average between 10 and 20 bushels to the acre. Higher yields than these are common. Some of the areas in the best locations are the equal of any of the valley lands. The light sandy or loamy texture of the soil makes it desirable because of ease of cultivation. It is also a warm soil, and having a close subsoil is retentive of moisture and fertilizers, to which it responds quickly. It is not droughty, and a crop is assured every year upon it. In the very stony or gravelly areas there is apt to be a deficiency of moisture, and as the soil is thin poor crops can be expected.

Usually fertilizers are put in with the wheat to start it. The soil as a rule does not seed readily to grass, except in favored situations, where blue grass will grow. It is better adapted to corn, of which it yields from 20 to 40 bushels per acre.

The Hagerstown stony loam is believed to be adapted to fruit growing. Peaches grown upon this soil, in the vicinity of Crosskeys, have been pronounced by commission men to be of superior quality. This fruit does well on the more sandy and stony phases of the soil and at the higher elevations. Many peach orchards, as well as apple orchards, have been already set out. The apple is said to do well, but at present there are but few bearing orchards, and these are not receiving the care they should to show the true capacity of the soil. There is little doubt that this soil is well adapted to fruit growing.

The greater part of this soil was regarded a few years ago as the poorest land in the valley, and sold for about $10 an acre. Now this same land, as a result of the development of the fruit industry, will bring at least $30 an acre, and the best of it, near the towns, brings as high a price as any of the valley soils.

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What little forest there is at present in the valley is upon this soil, the principal growth being white oak and chestnut.

Analyses of typical samples of this soil are given in the subjoined table:

Mechanical analyses of Hagerstown stony loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6536	½ mile S. of Kiracofe	Brown loam, 0 to 10 inches.	1.50	0.66	2.16	2.65	8.46	13.40	59.25	13.41
7233	¼ mile S. of Hermitage.	Fine gray loam, 0 to 12 inches.	1.55	2.70	4.94	3.64	7.28	14.08	44.86	21.96
7231	3 miles SE. of Harrisonburg.	Grayish loam, 0 to 7 inches.	2.59	1.74	3.88	2.18	4.34	9.40	51.22	26.34
6537	Subsoil of 6536......	Clay loam, 10 to 30 inches.	.88	3.98	3.12	1.69	6.77	12.60	49.23	22.58
7232	Subsoil of 7231......	Stiff yellow clay loam to clay, 7 to 24 inches.	.62	.68	1.32	.84	2.10	4.68	34.68	56.14
7234	Subsoil of 7233......	Yellowish-red clay loam to dark-red stiff clay, 12 to 36 inches.	.70	.40	1.74	1.14	2.46	4.92	22.50	66.28

HAGERSTOWN SANDY LOAM.

The Hagerstown sandy loam is a fine sandy loam, averaging 12 inches in depth, of a gray to yellowish or light-brown color, resting on a subsoil of yellowish-red clay loam grading into stiff red clay. The subsoil may sometimes consist entirely of stiff clay.

This soil is a valley soil, occurring in the Harrisonburg and Waynesboro sheets. It is found in numerous areas throughout the valley, those of greatest extent lying north of Elkton, on the lower slopes of mountains on both sides of the Shenandoah River. From that place this soil extends down the Shenandoah and South rivers.

The Hagerstown sandy loam occupies some of the higher ridges of the valley, the banks of the main river, and the lower slopes of the mountains. Its physiography insures good natural drainage. The subsoil, however, is quite retentive of moisture, and as the sandy covering acts as a mulch, crops as a rule do not suffer greatly from drought.

This type is both residual and colluvial in origin. The subsoil is derived from the weathering of limestone, giving rise to the same material as that found under the limestone soils already described,

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VIEW OF JARMANS GAP, IN THE BLUE RIDGE, WITH THE ROLLING PIEDMONT PLATEAU IN THE DISTANCE AND A DETACHED RANGE OF MOUNTAINS IN THE BACKGROUND, ALBEMARLE AREA, VIRGINIA.

The illustration gives an idea of one of the larger coves with apple orchards at an elevation of 2,000 feet.

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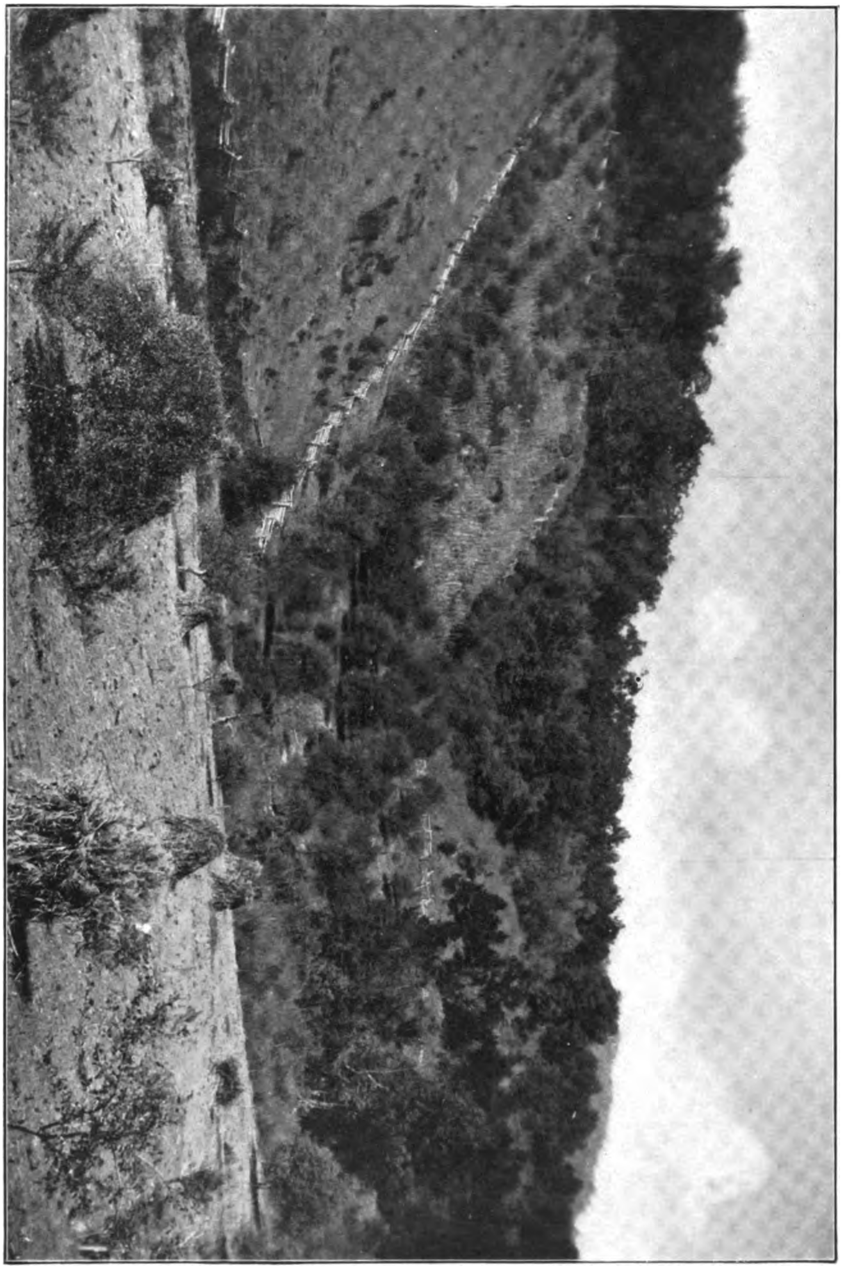

A SMALL COVE IN THE BLUE RIDGE, WITH APPLE TREES ON THE PORTERS BLACK LOAM, ALBEMARLE AREA, VIRGINIA.

In all such slight depressions, where the Porters black loam accumulates, apple trees are set out in the irregular areas covered by the soil.

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while the soil has been derived from material, spread over the limestone or its weathered product, deported from the sandstone cliffs of mountains by rain wash, or carried by the rivers and deposited at times of high water on the upland or as second bottoms. On the ridges in the valley the soil has been derived from shaly sandstone occurring in the beds of limestone. These beds are usually found on the tops of the ridges, and the disintegrated material has been spread over that of the limestone by wash of the rains. On these ridges sandstone bowlders are found, and on some of the ridges these sandstones have been broken into smaller angular blocks. Where this is the case the land is locally called "white gravel land," in distinction to the limestone gravel lands. These "white gravel" areas are not considered as good land as that derived from limestone.

Where the soil occurs on the lower mountain slopes there are usually present some rounded, subangular sandstone bowlders. The areas along the river are practically free from stones, and the soil is quite deep. Some of the best farms of the valley are located upon these areas. The gently rolling areas of this land nearer the rivers are desired for general farming. The sandy nature of the soil makes it easy of cultivation, and its subsoil, as noted in referring to the drainage features, is retentive of moisture and fertilizers, making it a comparatively sure soil for crops and one easily improved. Wheat, corn, and grasses are the crops grown. Wheat yields on the average from 15 to 20 bushels per acre, but in the poorer, lower areas on ridges and lower mountain slopes 10 bushels may be considered a good average yield. The yield of corn ranges from 30 to 50 bushels per acre. Grass and clover do fairly well. The ridges and lower slopes of mountains have been found to be especially well adapted to peaches. Several large orchards were seen that have proved successful financially. All the varieties of apples seem to do well. With the available good roads and fair railroad facilities there seems to be a bright outlook for this industry on this soil. Already factories are being built to can or evaporate the surplus product of the orchards.

The original forests upon this land were pine, but these have disappeared, mainly as the result of the attacks of an insect which a few years ago killed practically all the pines in the valley. Where covered now, the forests consist of hard-wood trees. In value this land ranges from $50 to $60 per acre.

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The following table gives mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Hagerstown sandy loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6534	1¼ miles SW. of Mount Clinton.	Yellowish sandy loam, 0 to 8 inches.	0.88	0.35	4.97	8.79	23.35	20.19	32.96	9.40
7215	3 miles NW. of Elkton.	Gray to light-brown sandy loam, 0 to 15 inches.	1.27	3.38	12.72	11.14	19.70	8.50	34.18	10.38
7217	2 miles S. of Hermitage.	Gray sandy loam, 0 to 12 inches.	1.46	.62	8.24	9.78	11.22	9.40	47.18	13.34
6535	Subsoil of 6534	Yellow or reddish-yellow clay loam, 8 to 36 inches.	.43	.42	3.23	5.37	15.71	12.68	24.08	38.53
7218	Subsoil of 7217	Yellowish-red clay loam to stiff red clay, 12 to 36 inches.	.48	.30	2.92	4.50	5.48	6.36	38.58	41.68
7216	Subsoil of 7215	Yellowish-red to red clay, 15 to 36 inches.	.71	.28	1.66	1.44	3.40	3.46	22.54	67.18

CONESTOGA CLAY.

The Conestoga clay consists of about 7 inches of yellowish to dark-brown clay loam, resting on a reddish-yellow and sometimes red, stiff, tenacious clay, usually not exceeding a depth of 24 inches, while on ridges the rock is usually found at an average depth of 10 inches. The soil, when wet, is very sticky, and in the shallower places there is no line of demarcation between the soil and the subsoil, the soil gradually becoming stiffer as the depth increases. The subsoil has a cold, greasy feel, and the farmers speak of the type as a "cold and unkind" soil.

Shaly fragments are usually found upon the surface and throughout the soil and subsoil. The proportion of such material varies from a mere trace to as high as 20 per cent of the soil mass.

The Conestoga clay occurs in the valley in both the Harrisonburg and Waynesboro sheets. The areas are long and narrow, following the general direction of the valley formations. There are three principal areas and two of less importance. The largest area occupies the low ridge and slope immediately west of Harrisonburg and follows the ridge to the southwest, becoming wider as it passes out of the area. At Harrisonburg this ridge is low and rolling, but to the south it

becomes higher and breaks into a series of steep ridges and hills. The two other principal areas occur on each side of the shale formation. The one on the west is about a quarter of a mile wide, extending from Crosskeys to the southwest and passing out of the area, while the area on the east of the shale formation averages one-half mile or more in width and extends from McGaheysville southwest and also passes beyond the limits of the survey. A small strip of this soil is found west of Crosskeys. These strips occupy lower and gently rolling parts of the valley and are therefore tillable.

The higher parts of areas of this soil have good surface drainage, but the strips occurring along the shale boundaries, being nearly level, need artificial drainage. Tile drains are now being put in and are found to greatly improve the condition of this soil.

The Conestoga clay is of residual origin, being derived from a schistose or shaly limestone, locally called "blue" or "black" slate. From this the soil gets the local name of "black-slate land." This schistose or slaty formation was probably developed by great pressure and in the changes that took place in the valley was tilted up on edge. It does not weather deeply, and usually there is only a slight covering of decomposed rock, so that the fresh rock is found immediately below the soil. On the ridges the ribs of rock outcrop and the soil is shallow, but lower down on the slopes the soil becomes much deeper.

The Conestoga clay is the heaviest and most intractable of the valley soils and requires careful treatment to produce good crops. Like the heavy limestone clays, this soil is much benefited by fall plowing, and it is essential that this be done to get the best tilth. When plowed in the spring, while wet, the soil breaks up into clods. Upon drying the soil becomes hard and cracks, and crops suffer for moisture when the season is at all dry. The crops best adapted to the Conestoga clay are wheat and grass. When given proper treatment and a favorable season the yield of wheat is greater than on any other soil, averaging as high as 40 bushels to the acre. From year to year the yield averages from 25 to 30 bushels. The wheat is of superior quality. Yields of from 2 to 3 tons per acre of timothy are obtained. Clover also does well. The soil naturally runs to blue grass, and much of the area is best adapted to pasturage.

Barnyard manure and other coarse material greatly improve the physical condition of this soil. Lime also has a beneficial action upon its texture. The soil is very retentive of fertilizers. Farm lands sell at from $30 to $100 per acre, depending upon location.

The table annexed gives the results of mechanical analyses of the soil and subsoil of this type.

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Mechanical analyses of Conestoga clay.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7193	1 mile S. of Harrisonburg.	Yellow clay loam, 0 to 6 inches.	1.60	1.18	3.14	2.02	2.78	4.26	56.08	30.26
7696	1¼ miles SW. of Newhope.	Heavy, sticky, brownish loam, 0 to 8 inches.	2.18	2.84	3.64	1.80	2.40	3.06	44.98	41.10
7214	1 mile S. of Dayton.	Heavy yellowish clay loam to clay, 0 to 22 inches.	.47	2.70	5.20	2.96	5.30	3.86	36.20	43.78
7212	¼ mile E. of Mount Sidney.	Heavy yellowish clay loam, 0 to 7 inches.	2.05	3.08	4.74	2.48	2.30	3.32	34.88	48.74
7213	Subsoil of 7212	Stiff yellow clay, 7 to 22 inches.	1.26	.82	3.06	2.38	3.00	2.14	45.46	43.14
7194	Subsoil of 7193	Yellowish clay, 6 to 36 inches.	.48	1.70	5.06	3.02	3.60	2.42	30.70	53.28
7697	Subsoil of 7696	Stiff yellowish-red clay, 8 to 36 inches.	.94	.94	1.92	1.00	1.50	1.84	35.40	56.66

HAGERSTOWN SHALE LOAM.

The Hagerstown shale loam occurs in all of the physiographic divisions found within the area and in each of the three sheets of the soil map. It consists of a yellowish loam or clay loam, increasing in clay content in lower depths and becoming generally a stiff clay, resting upon a mass of broken, weathered shale. The depth of soil and subsoil does not generally exceed 24 inches. Shale fragments are found scattered through the soil and upon the surface, where the amount varies from a trace to 25 per cent in the better areas, but in some localities in the shale hills the soil is little more than a mass of broken shale with some yellow clay loam or clay intermixed. Such areas afford only a scanty hold for the growing vegetation, and the best of the mountain areas are not much better.

The depth of the soil in the mountain area rarely exceeds 15 inches, and usually it is about 8 inches. The soil is also influenced by the presence of sand coming from the strata of sandstone interbedded with the shale. Sandstone sometimes caps these small mountains, and sandstone bowlders are found scattered over the shale.

In the Piedmont division the soil is much like that of the valley, except that it is of lighter texture, and as a whole contains a larger percentage of shale fragments. On the higher ridges quartz is abundant. Sometimes the fragments, which are usually small, cover the entire surface, and then there is a layer, rarely exceeding 3 inches in

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thickness, of grayish sand derived from this quartz resting upon the loam.

In the valley the Hagerstown shale loam occurs in a broad belt, coming into the area near Fishersville on the Waynesboro sheet and extending to the northeast into the Harrisonburg sheet to Massanutten Mountain, where it divides, surrounding that mountain at the base.

The occurrence of this type in the mountain division is between the sandstone and schist formations. There it forms a chain of areas extending from the Buckingham sheet into and through the Waynesboro and Harrisonburg sheets.

This soil in the Piedmont division occurs only on the Buckingham sheet. As in the valley, the area is a broad belt. It extends from Mount Alto to the northeast along the eastern boundary of Green Mountain and passes out of the area.

The topography of the soil in the valley is characteristic of the shale formations, consisting of a series of hills of uniform elevation and generally smooth contour and gentle slope. Toward Massanutten Mountain the surface is gently rolling, the type extending onto the gentle lower slopes of this mountain.

In the mountain area the soil forms a series of small mountains or ridges. The surface is smooth, and except where sandstone is abundant is generally free of bowlders. The topography in the Piedmont area is much like that of the valley.

The valley area is drained mainly by Middle River, which takes a winding course through it. A few large streams flow into this river, and into these empty many small and short streams from each side. The absence of bottom land along these streams is noticeable. The large number of streams affords thorough and rapid drainage.

The broken condition of the underlying shale formation allows free passage of the ground water. In the shallower and more shaly locations this drainage is so rapid that there is rarely any excess of moisture in the soil, and generally it is deficient.

The Hagerstown shale loam is a residual soil, derived from the weathering of shale. The rock varies from argillaceous to sandy. The weathered argillaceous shale in the valley is locally known as "soapstone shale," as it has a smooth, greasy feel. The shale of the Piedmont belongs to the Triassic period, and also varies in character from argillaceous to sandy. It also varies greatly in color, from which the land has become known as "mixed-slate land." Slate of an inferior quality is quarried near Esmont.

The Hagerstown shale loam is best adapted to the production of wheat and is largely devoted to this crop. In the valley the yield per acre is sometimes as high as 45 bushels. The average yield, taking good and poor seasons together, is not more than 15 bushels per acre. Corn does fairly well in favorable seasons, but usually the soil is too dry for this summer crop. The land is best adapted to those crops

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which are harvested before dry weather comes or which can tide over the period of drought. When clayey enough and of sufficient depth the soil is well adapted to grass. The areas derived from the "soapstone" shale are considered the best for this crop. Timothy will yield on an average over a ton to the acre, and blue-grass grows naturally. A rotation of crops, consisting of corn, wheat two years, and grass four or five years, is usually followed. On the poorer areas corn is left out of the rotation. In the valley the price of this soil ranges from $40 to $75 an acre.

On the slope of Massanutten Mountain this land is of little importance. It is cleared and cultivated, but the yields are small, not over 5 to 10 bushels of wheat in favorable years. Possibly the better areas might be used in the growing of grapes.

The mountain areas of this soil in the Blue Ridge are considered of so little value that they are not even cleared, but are left in the original forests, consisting of a scrubby growth of oak, chestnut, and locust.

In the Piedmont area the soil is mostly forested, and its value varies greatly. Most of it will not bring over $3 an acre, while some of it, in favorable localities, brings as high as $15 to $30 an acre. The best of the Piedmont areas will not yield over 10 bushels of wheat per acre. Some of these will grow grass. The more sandy and higher lying areas are said to produce excellent fruit, especially peaches, but there are no commercial orchards established on the type at present. All the products grown on the Hagerstown shale loam, in the different divisions, are always of superior quality.

Mechanical analyses of typical samples of this soil from the different physiographic divisions of the area are shown in the following table:

Mechanical analyses of Hagerstown shale loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7209	2 miles W. of Montevideo.	Yellow clay loam, 0 to 18 inches.	0.76	2.94	2.74	1.84	6.94	12.72	38.62	33.76
7211	5 miles S. of Elkton.	Yellow light clay loam, 0 to 18 inches.	1.10	4.90	2.54	1.30	4.80	7.58	39.24	39.26
7698	1 mile E. of Esmont.	Brown loam, 0 to 8 inches.	3.04	.66	2.02	1.70	3.60	5.98	45.94	39.60
7210	1 mile E. of Fort Defiance.	Yellowish clay loam to stiff clay, 0 to 22 inches.	1.51	2.40	2.70	1.30	2.26	3.84	44.08	43.36
7699	Subsoil of 7698......	Yellow clay loam, 8 to 20 inches.	1.14	1.58	2.08	1.08	2.50	4.84	37.22	50.60

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EDGEMONT STONY LOAM.

The soil of the Edgemont stony loam consists of a gray to yellowish sandy loam with an average depth of 8 inches. The subsoil is a yellowish sandy loam with an average depth of rarely more than 20 inches, resting upon either a mass of broken sandstone or rounded, waterworn sandstone bowlders. These sandstone bowlders also occur throughout the soil and subsoil and upon the surface, their character and quantity varying in different localities. The greatest proportion of bowlders is found in the area occupying the long, gentle talus slope extending from the foot of the steep western slope of the mountains to the Shenandoah River, where they probably make up 60 per cent of the soil mass. There are, however, occasional areas that are free from bowlders and have a subsoil becoming quite clayey in the lower depths.

The Edgemont stony loam has a greater extent than any other of the mountain soils, occurring in each of the three sheets of the soil map. The area is a broad, continuous belt forming the western flank of the Blue Ridge Mountains.

The physiographic features consist of sharp peaks and ridges, with either vertical cliffs or steep, stony slopes. The elevation ranges from 1,700 feet on some of the lower ridges or foothills to a little over 3,000 feet on the higher peaks of the main ridges. Extending from the foot of the mountains there is a gentle talus slope, averaging in width from 3 to 4 miles, the change in elevation in that distance being only 200 or 300 feet. This talus slope has been subjected to the action of water, probably while forming a shore line of an inland sea. The bowlders and pebbles are all rounded, plainly showing the action of water. Assortment has also taken place in their deposition, as shown by the strata seen in railroad cuts. The stone-free portions were probably sand bars on the beach of this inland sea. Many streams cross the area, but most of them contain water only part of the year.

The sandy and stony nature of this formation and the underlying mass of bowlders, together with its topographic position, afford rapid and thorough drainage, and this soil rarely contains an excess of moisture.

The areas of the Edgemont stony loam are so steep and stony that only rarely can they be cultivated, and then only with difficulty. The soil is of so little agricultural value that it is allowed to remain in forest. The land is so thin that it can support only a light forest growth. This consists mostly of oak and chestnut, with an undergrowth of huckleberries. On the lower mountain slopes and the long talus slope particularly referred to above there are great numbers of chinquapin bushes. The huckleberries and chinquapins can be said at present to furnish about all the income that comes from this land. There is some cleared land on the long talus slope, but it is not very

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productive, and owing to texture can not be permanently enriched or brought to a higher state of cultivation. No good farms are seen on the type, and the buildings are not of the best. Much of this land is either owned in small holdings or rented by negroes, who manage to make a living upon it.

The best cereal crop they can grow is rye, which yields from 6 to 15 bushels per acre. Corn does not do well, as it suffers from drought. The stony character of the soil makes it very difficult to till. Near the mountains damson plums are said to do well. The value of these lands ranges from $2 to $10 per acre.

On the areas free from stones fairly good crops of wheat and corn are obtained. Grass is also grown in some of the better areas. This part of the type would probably make good truck soil. There is direct railroad connection to the north, giving good facilities for marketing.

The value of this phase of the Edgemont stony loam is much above the average, bringing when improved as high as $50 or more an acre.

The lower and gentler slopes of the mountains and foothills are probably adapted to the culture of peaches. Individual peach trees are of thrifty growth and bear heavily. The people believe it to be a good peach soil, but are deterred from embarking in the industry by the efforts necessary to combat diseases. Another reason advanced is that the trees are short lived, not lasting more than five or six years. The early death of the trees is attributed to the effects of the climate, but it is probably due to lack of proper care of the trees. The eastern slope, which is sheltered from cold winds, probably offers the best locations for orchards. It is upon this soil in Maryland that the successful peach orchards are established.

Wild grapes grow luxuriantly on this soil, and it may be that the cultivated varieties can be profitably produced on it.

The value of the mountain lands varies from 50 cents to $5 per acre, the latter price being for foothill areas near Basic City.

The table on page 209 gives the results of mechanical analyses of samples of the soil and subsoil of this type:

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Mechanical analyses of Edgemont stony loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7242	2½ miles SW. of Elkton.	Fine gray to yellowish sandy loam, 0 to 10 inches.	1.62	0.34	2.04	5.20	31.80	23.20	23.38	13.48
7230	½ mile S. of Basic City.	Yellowish sandy loam, 0 to 15 inches.	2.94	1.60	8.32	8.64	21.86	20.66	24.48	14.44
7240	½ mile S. of Elkton..	Gray to yellowish sandy loam, 0 to 10 inches.	2.46	3.40	11.10	9.04	17.70	10.80	33.36	14.64
7226	1½ miles SW. of Fridley Gap.	Grayish sandy loam, 0 to 10 inches.	1.64	4.44	11.98	11.00	17.10	7.28	27.84	20.20
7244	1 mile N. of Basic City.	Gray sandy loam, 0 to 12 inches.	.65	3.10	8.34	6.40	15.40	15.14	28.28	23.14
7227	Subsoil of 7226......	Coarse yellowish sandy loam, 10 to 20 inches.	.40	5.08	11.84	10.34	16.94	7.24	27.96	20.16
7243	Subsoil of 7242......	Fine yellow sandy loam, 10 to 36 inches.	.36	.34	2.26	5.04	27.94	19.74	23.84	20.30
7245	Subsoil of 7244......	Yellow sandy loam, 12 to 28 inches.	.74	2.60	9.14	7.58	18.40	15.44	22.96	23.12
7241	Subsoil of 7240......	Yellow sandy loam, 10 to 26 inches.	.32	3.44	7.96	7.86	16.66	11.84	19.40	31.92

PORTERS BLACK LOAM.

The soil of the Porters black loam is a loose, mellow, dark-brown to jet-black loam, averaging about 12 inches in depth. The subsoil is a loam of slightly heavier texture and of a light-brown to yellowish color. On the tops and slopes of the mountains it usually does not exceed 36 inches in depth, but sometimes it may reach the depth of several feet. In depressions and stony places on the tops and slopes, and in coves, the soil is much deeper. In these locations there is no distinct demarcation between the soil and subsoil, the loose black loam being often 10 feet or more in depth. This is due to the situation of the areas in places where the loam and decaying vegetation washed down from the higher slopes has collected. The color of this soil is due for the most part to the presence of comparatively large proportions of organic matter. This forest mold also probably accounts for the mellowness of the soil, which differs from true forest mold in that even after it has been cultivated for many years it still retains its color and friable texture.

In the Ragged Mountains this soil is sometimes a fine sandy loam

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of a nearly jet-black color and containing considerable quantities of mica.

In the soil and subsoil are small fragments of the rocks from which this type has been derived. In the Blue Ridge proper large slabs of a fine-grained blue schist are found upon the surface, and outcrops are also numerous. Generally the surface is free enough from stones to be tillable. On the foothills and small mountains as high as 60 per cent of granitic or gneissoid rocks are sometimes found in the soil, but the average would probably not be more than 20 per cent.

The Porters black loam occurs in all of the soil survey sheets, extending along the top of the main portion of the Blue Ridge Mountains in one continuous area. Small areas are numerous in foothills and detached ranges in the Piedmont Plateau, most of these being within the boundaries of the Buckingham sheet. The small areas mapped occur in the coves. Not all the areas of this type could be mapped, as they were often too small to be shown on a map of the scale used. Practically nearly every cove in the Ragged Mountains contains some of this soil.

This type consists of the broad rolling tops and the upper slopes of the main range of the Blue Ridge Mountains. Its elevation there ranges from 2,000 to 4,000 feet above sea level. In the detached mountains of the Piedmont the soil occurs in the coves, and the elevations range from 800 to 2,500 feet above sea level.

The Porters black loam is residual in origin, being derived in the the Blue Ridge proper from the weathering of schist. This schist is a fine-grained, blue-colored variety, most of it containing epidote, to which mineral has been ascribed the fertility of the soil. In the smaller mountains the type has been derived from a coarse-grained granite, and probably also a gneiss or gneissoid granite. These rocks are said to be rich in potash feldspars.

Locally the Porters black loam is called "black land" and "pippin land," the latter term being applied because, of all the soils of the area, it is preeminently adapted to the production of the Newtown or Albemarle Pippin. This black land has long been recognized as the most fertile of the mountain soils. It can be worked year after year without apparent impairment of its fertility. On the Blue Ridge proper, prior to the civil war, dark shipping tobacco was extensively grown on this soil. The tobacco was of superior quality, much of it grading as a fine wrapper. At present this crop is not cultivated.

This soil is not adapted to wheat or corn. Wheat winterkills, the loose soils heaving badly under influence of frost. The areas lie at too high elevations for corn. Oats do well, making large yields. Buckwheat is said to do well, but very little has ever been grown. Irish potatoes, even under ordinary culture, will yield from 200 to 300 bushels an acre. These potatoes are smooth and of good quality.

The soil is best adapted to grazing, and to that use it is now chiefly

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devoted. It seeds to blue-grass naturally, which affords excellent pasturage. Clover and other grasses will also grow luxuriantly upon it. The often remote situation and great elevation make it difficult to handle the general farm crops. This fact, together with its natural adaptation to the production of the grasses, makes the Porters black loam first of all a grazing land. The areas occupied by this soil are mostly cleared. On mountain tops the land is popularly known as "chestnut levels," that tree being the predominant growth.

The tops and higher slopes of the mountains are not adapted to fruit growing, because of the unfavorable climatic conditions, due to the exposed position and high elevation. At the higher elevations ice, sleet, and heavy snowstorms are frequent, and would do much injury to the orchards. The trees make a thrifty growth, but it is only under the best conditions that a crop can be secured. The black cherry does well, however, on the mountain tops.

Lower down, on the eastern slope, are bearing orchards. (See Pls. VI and VII.) The western slope is too much exposed for fruit, nor does it produce any crop as well as the eastern slope, because of the unfavorable climatic conditions.

The value of the Porters black loam in the Blue Ridge ranges from $5 to $25 an acre.

It is the "black land" in the coves of the Ragged Mountains that is considered the best "pippin soil." These coves, besides having a deep soil, also have an elevation suited to the production of superior fruit. The areas are usually sheltered from cold winds. Other varieties, including the red winter apples, also do well in these coves, providing there is plenty of sunshine to develop the color. Peaches of all varieties do well, the chief objection being a somewhat too rank growth of the trees. The Belyeu Comet, which is strictly a mountain peach, is probably the most profitable. The peach trees are planted alternately with apple trees, and by the time the latter need all the space the peach trees are ready to be removed.

The forest growth in these coves is the heaviest in the area, and consists of chestnut, poplar, walnut, butternut, hickory, and oak.

The value of this cove land is difficult to estimate, as it occurs in small areas and is sold with adjoining poorer land. The average price for such tracts ranges from $5 to $10 per acre.

The table following shows the texture of typical samples of the soil and subsoil of the Porters black loam.

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Mechanical analyses of Porters black loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7223	3 miles S. of Ivy Depot.	Loose dark-brown or black loam, 0 to 36 inches.	1.87	1.94	5.62	4.76	21.08	24.28	22.98	19.52
7222	3 miles S. of Miller School.	Loose dark-brown loam, 0 to 34 inches.	4.90	5.90	12.40	8.64	13.36	10.16	23.26	25.74
7221	.....do...............	Loose dark-brown loam, 0 to 22 inches.	4.74	4.56	10.88	7.24	15.44	12.64	21.96	27.48
7219	½ mile SW. of Rockfish Gap.	Mellow dark-brown loam, 0 to 10 inches.	4.56	2.14	5.06	2.42	6.16	9.62	26.76	48.18
7220	Subsoil of 7219......	Brown to yellow loam, 10 to 36 inches.	.70	2.96	5.20	2.90	7.50	13.10	28.44	39.08

PORTERS CLAY.

The Porters clay is a dark reddish-brown loam to clay loam from 6 to 12 inches in depth, resting on a subsoil of dark-red clay loam or stiff, tenacious clay. Usually the soil and subsoil exceed a depth of 36 inches, but on some of the steeper slopes, where there has been no chance for collection, the underlying rock is often found within 15 inches of the surface. In the stony places the soil is more loamy and the subsoil is only slightly heavier, but when the formation is deep the subsoil becomes a stiff clay. On the lower slopes the latter phase is the most common. In the upper parts of the areas the soil grades imperceptibly into the Porters black loam.

Upon the surface rock fragments and bowlders are usually found, but in varying quantities, sometimes occupying as much as 60 per cent of the surface. The higher elevations are generally the more stony.

The Porters clay occurs on each of the three sheets of the soil map as a nearly continuous belt occupying the lower slope on the eastern side of the Blue Ridge Mountains to Simmons Gap, when it breaks, and is then continued on the western lower slope, passing out of the area. A small area occupies the top of Carters Mountain, on the eastern boundary of the area.

The surface features of this soil type are those of the mountain slopes. The lower limit of elevation averages about 1,000 feet above sea level, and the upper elevation is found close to the 2,000-foot contour. On Carters Mountain it occupies the top and upper slopes. On account of its physiographic position the areas all have good surface drainage.

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The Porters clay is a residual soil, derived from the weathering of the Catoctin schist, the chlorite variety being the most prominent in the formation of this soil.

The Porters clay ranks next to the Porters black loam in fertility and agricultural value. It is often spoken of as "mountain red land," in distinction to the red land of the Piedmont or "flatwoods" section. It is similar to the Green Mountain land, being derived from the same kinds of rock, but, occurring on the mountain slopes and in general being more stony, it has been classed as a different type. The less stony and steep situations are of about equal agricultural value to the Green Mountain land. The same crops are grown and nearly as good yields are obtained. Wheat, corn, and the grasses are the chief crops grown upon it. It has been used to some extent for the production of tobacco. Because of its location it is much better adapted to grazing than to the cultivated crops. It is now being developed as a fruit soil, especially the area lying between Jarmans Gap and Humpback Mountain. In the more loamy areas apples do well. On the upper parts of areas, where the soil approaches that of the Porters black loam, it grows good pippins. The chief objection to this soil is that most of it is too steep for cultivation. It is difficult to cultivate and spray the trees and to harvest the fruit. Areas that can be used for orchards bring from $5 to $20 an acre, including forested and cleared land, but not lands set in orchards. This soil supports a heavy growth of the various hardwood trees.

The following table shows the texture of soil and subsoil of this type:

Mechanical analyses of Porters clay.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7166	2¼ miles W. of Crozet.	Dark-brown loam, 0 to 12 inches.	3.87	2.18	2.96	1.82	4.32	7.46	52.82	28.38
7172	3¼ miles SE. of Elkton.	Dark reddish-brown loam, 0 to 10 inches.	2.47	1.82	3.30	2.08	4.34	4.88	45.48	38.04
7168	1¼ miles SW. of Afton.	Heavy dark reddish-brown loam, 0 to 10 inches.	1.94	2.08	3.30	1.78	3.60	4.16	29.18	55.90
7167	Subsoil of 7166......	Dark reddish-brown loam to dark-red clay, 12 to 36 inches.	.98	.68	1.62	.96	2.94	4.50	34.90	54.30
7169	Subsoil of 7168......	Dark reddish-brown loam to clay loam, 10 to 36 inches.	1.12	1.34	2.06	1.10	2.08	3.92	26.72	61.98
7173	Subsoil of 7172......	Dark-red clay loam, 10 to 36 inches.	.84	.42	1.04	.66	1.88	2.70	28.72	64.56

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PORTERS SAND.

The Porters sand, another mountain type, consists of a gray or yellowish sand, averaging 8 inches in depth, underlain by a generally coarse, yellowish sand that runs into the disintegrated rock at depths usually less than 36 inches. Usually the depth to rock does not exceed 24 inches. The soil is shallower in higher, steeper locations, while in lower, less-inclined areas it becomes quite deep.

In both soil and subsoil a large proportion of rock fragments are present, and upon the surface bowlders are scattered. On the lower slopes the fragments are smaller, giving the soil a gravelly character. Sometimes the soil consists almost entirely of coarse crystals of feldspar and quartz. The steeper areas contain so many bowlders and outcrops that they are of no agricultural value.

In some locations, especially in depressions, the soil becomes quite loamy, due to the accumulation of organic matter.

In portions of the Ragged Mountains, where this soil has been derived from a variety of granite known as granulite, the soil is a light to dark-brown sandy loam, underlain by sandy loam of a dark yellowish and occasionally reddish color, running into disintegrated rock at a depth of about 24 inches. Both the soil and subsoil contain a large quantity of mica, giving them a greasy feel.

The soil of the forested areas often contains so much forest mold as to be quite black. Such areas are called "black land," but, unlike the Porters black loam, after being cultivated a few years the soil loses its dark color, becoming then what is locally called "gray land."

This type occurs in many irregular-shaped areas on each of the three sheets, occupying the spurs and foothills of the Blue Ridge Mountains, and the small detached ranges in the Piedmont Plateau.

The main physiographic features are sharp spurs and knobs and the usual configuration of the foothills east of the Blue Ridge Mountains. As a rule these are very stony, and their sides in some cases are nearly vertical cliffs of granite. The physiography is best described by the word "rugged."

The Porters sand is a residual soil, derived from the weathering of granites varying in texture from coarse grained to fine grained. The coarser rocks are popularly known as "calico rock," while one variety, "granulite," is sometimes called a sandstone. The weathering of these rocks has chiefly been through disintegration where they contain a large percentage of quartz, while where feldspar is a more important element both disintegration and chemical decomposition have entered into the formation of the residual products.

This soil is in general too steep and stony to cultivate, is of practically no agricultural value, and consequently is left in forest, consisting of a quite heavy growth of oak and chestnut, valued to some

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extent for lumber and tanbark. However, the difficulties to overcome in removing the timber are so great that the land is of comparatively little value for these products. Much of it is too rough to be used for pasture.

It is only on the smoother and less stony slopes of the foothills and detached ranges that the land is cleared and worked, and even there it can not be considered a desirable soil for general farming. Within the last few years, however, it has been found to be adapted to the production of peaches and small fruits, and this interest, where good railroad facilities are available, is now being developed. Many orchards have been planted and have come into bearing. The trees are thrifty and bear well and the fruit is of fine quality. All the varieties of peaches, from the earliest to the latest, are grown successfully, but it has been found most profitable to grow the Elberta and Belyeu Comet. The former generally ripens at a time when there is a lull in the marketing of northern peaches, and consequently brings fair prices. The latter is adapted especially to mountain situations, is the latest peach in the market, and having no competition brings in good returns. There is now a movement afoot to export this variety, which is a good shipper, to Europe and especially to England. The slopes with elevations between 1,000 and 1,500 feet above sea level are best for peaches.

Small fruits do well. Strawberries are in some instances grown between the rows of peach trees.

On the stony areas, where the soil is quite loamy and deep, Albemarle pippins have been found to do well. Pippins of excellent quality have been produced on the sandiest phases of this soil, but a crop is not assured every bearing year, as on the Porters black loam, and fertilization is necessary to keep the trees growing. As a whole, this soil type can not be considered an apple soil. The orchards should be limited to those phases having a more clayey subsoil and to the micaceous sandy loam phase.

There is a large area of the Porters sand, and the most of it can be bought for prices ranging from $3 to $5 an acre. Near the railroads these prices are greatly exceeded.

The table on the following page shows the results of mechanical analyses of samples of the soil and subsoil of Porters sand.

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Mechanical analyses of Porters sand.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7713	4 miles SW. of Charlottesville.	Brown sandy loam, 0 to 10 inches.	3.27	7.10	16.40	10.52	21.26	10.46	22.98	9.66
7174	¾ mile NW. of Crozet.	Gray sandy loam, 0 to 8 inches.	1.23	13.96	20.00	10.26	16.04	7.56	21.84	10.22
7176	½ mile S. of Afton...	Yellowish sandy loam, 0 to 8 inches.	2.53	4.16	10.42	10.46	22.62	10.80	29.96	11.58
7714	Subsoil of 7713......	Yellowish sandy loam, 10 to 24 inches.	.68	10.66	14.46	9.84	18.70	9.82	24.24	11.68
7175	Subsoil of 7174......	Yellowish sandy loam, 8 to 24 inches.	.20	9.56	15.04	8.66	14.90	7.78	29.80	14.26
7177	Subsoil of 7176......	Yellow sandy loam, 8 to 32 inches.	.71	2.40	8.10	8.76	19.64	10.08	33.64	17.38

CECIL CLAY.

The soil of the Cecil clay varies from a brown to reddish or dark brown loam or clay loam, averaging about 8 inches in depth. The subsoil is a dark-red clay loam, grading into stiff, tenacious red clay, 36 inches or more in depth. This type is generally known as "red land," and some areas, occupying the level table-lands in the vicinity of Ivy Creek and southwest of Crozet, are known as "chocolate land" because of its chocolate-brown color. The color of the clay subsoil of the latter phase is also darker than the typical Cecil clay subsoil.

Quartz sand and fragments are present in both soil and subsoil, and angular fragments are found upon the surface. These fragments often form as much as 60 per cent of the surface.

This soil is found in the Piedmont area, in each of the three sheets of the soil map, but principally in the Buckingham and Waynesboro sheets. The greatest extent of this type is found in the Buckingham sheet. There is one large area occupying the Green Mountains—extensions of the Southwest Mountains. This strip is from 1 to 3 miles wide, extending from the southern boundary of the survey, west of Mount Alto, northeastward and following the mountain, here only a ridge, out of the area. The other large areas are in Nelson County. These are irregular in shape, as are also those areas occurring in Albemarle County in the Waynesboro sheet. The latter areas generally occupy the uplands of the different creeks and rivers north of Ivy. On the Harrisonburg sheet the only occurrence of this soil is along Roach River.

The Cecil clay has chiefly the configuration of uplands of the Piedmont Plateau. Where the areas are near large streams the formation

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has the characteristic hilly topography. In places the soil extends up the lower slopes of the Blue Ridge and foothills. It is found also on the top and on long, gentle slopes of the Green Mountains.

This soil generally has good surface drainage, as may be inferred from its rolling surface, although the more level areas could be much improved by artificial drainage.

In origin this soil is both residual and sedimentary. It is derived from igneous and metamorphic rocks. Granite, diabase, and diorite, with some mica schist, chiefly enter into its derivation, while the strip occupying the Green Mountains has been formed from fine-grained schist, dark blue or greenish in color, known as the Catoctin schist. This schist is rich in chlorite and epidote. These rock formations have weathered to great depths, as shown in sections of wells. The areas of sedimentary origin are formed of deposits from the schist of the Green Mountains, and have resulted from the wash of both slopes. This sediment has been spread over the material of the mica schists, and varies from a mere covering to a mantle several feet in thickness. Usually where the coating is but slight the mica-schist formation has influenced the soil enough to make the texture noticeably more loamy, and such areas have been mapped as Cecil loam. On the slopes most of this covering has been removed by washing, while that on the upland remains.

The Cecil clay is considered the most desirable of the Piedmont soils for general farming. It is a heavy soil and best adapted to wheat, tobacco, and grass. Most of the Cecil clay lands have a local designation and reputation. Thus the lands along Ivy, Buck Mountain, and Beaverdam creeks are locally named after these creeks. The level uplands are often spoken of as "chocolate land." These are recognized as the best lands of the section. Heavy shipping tobacco was formerly the main crop, yielding on the average from 1,000 to 1,200 pounds to the acre. Wheat and clover were grown in rotation with the tobacco. In the Ivy and Beaverdam creek areas there is still some heavy export tobacco grown. The abandonment of tobacco growing has been due mostly to scarcity of labor. The yield of wheat, taking the whole area into consideration, will average 8 bushels an acre, but in the better cultivated areas the yield is much higher. In fact, the yield can be made equal to some of the valley soils. Except on the heavier phases corn does fairly well. The grasses and clovers produce well upon this soil if they are once well established. The fertile Green Mountain area is recognized as the one best adapted to the hay and forage crops. It is the heaviest phase of the Cecil clay in the area and is difficult to cultivate, not scouring well on the plow. A great deal of the area is used for pasture. Timothy and orchard grass yield from 1 to 2 tons or even more per acre. Blue-grass is also grown.

The red varieties of apples and some varieties of grapes do well upon the Green Mountain area, except where the subsoil is exceed-

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ingly stiff. All the grapes grown on a commercial scale within and just out of the area surveyed are grown on the Green Mountain soil. The more loamy areas on the eastern slopes are usually chosen for the vineyards.

Near the Blue Ridge Mountains, in those sections where the soil has been derived from a coarse-grained granite locally known as "calico rock," it is considered very fertile land and produces good crops. It is also excellent fruit land. The red varieties of apples do best, especially the Winesap. Peaches are also produced successfully.

The areas of this soil can be identified by the bowlders of the parent rock usually present on the surface. The fertility of this phase of the Cecil clay is ascribed to the comparatively large proportion of potash and phosphate of lime contained in the rocks, these breaking down enough each season to replace the elements withdrawn by the crops.

Over the whole area the Cecil clay is a strong soil, and with proper handling is very productive. It is retentive of moisture and fertilizers and is capable of being brought to a high state of cultivation. The soil is much improved by the use of green manures. Crops suffer some in times of drought, but still not as much as on the heavy valley soils.

The value of Cecil clay varies greatly. The areas in more remote situations do not bring over $10, while improved farms near railroad stations bring as high as $100 an acre.

The following table shows the results of mechanical analyses of samples of the soil and subsoil of the Cecil clay:

Mechanical analyses of Cecil clay.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7181	4 miles NE. of Owensville.	Reddish loam, 0 to 8 inches.	1.85	2.84	4.38	5.22	24.54	17.04	24.72	20.90
7179	Cross-roads SE. of Moormans River.	Heavy dark clay loam, 0 to 8 inches.	3.16	.92	3.78	4.36	10.04	5.62	37.84	37.44
7692	1½ miles NW. of Esmont.	Heavy dark-red loam, 0 to 8 inches.	2.16	.50	2.10	1.94	6.88	10.10	31.02	47.54
7180	Subsoil of 7179	Stiff dark-red clay, 8 to 36 inches.	.95	.40	2.38	2.86	5.62	2.88	41.24	44.20
7182	Subsoil of 7181	Red clay loam or clay, 8 to 36 inches.	.42	.92	1.88	1.82	8.46	6.16	28.38	52.38
7693	Subsoil of 7692	Stiff dark-red clay. 8 to 36 inches.	.57	.56	.66	.80	2.76	4.88	18.20	71.54

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CECIL LOAM.

The soil of the Cecil loam varies greatly in color. The greater part of it is of a yellowish, light or dark brown, reddish-brown, or red color. The depth of the surface soil varies from 6 to 12 inches. The average depth is probably about 10 inches. There is usually some fine sand in the soil, and occasionally the proportion is great enough to give the soil a somewhat sandy character. The subsoil also varies in color and texture. However, there are but two principal phases. The typical one is a yellowish, occasionally slightly reddish, loam, grading into the rotten rock (a mica schist) at a depth generally less than 36 inches. In the upper part of this loam subsoil there is a stratum of heavy texture, varying from a clay loam to quite stiff clay loam, but beneath this the subsoil becomes lighter as depth increases. The soil and subsoil contain a large quantity of finely divided mica. This lighter and typical phase of the Cecil loam occupies the steeper slopes, where washing has been pronounced. The soil in these situations is little more than the decomposed mica schist. Owing to the steepness of the slopes, it has little agricultural value.

The heavier phase of the Cecil loam, occurring on the uplands and more gentle slopes, consists of a loam to clay loam, sometimes becoming quite stiff, but, in distinction to the red-clay land, instead of increasing in clay content with depth, it usually becomes more micaceous and lighter. The color of this phase is yellowish red to dark red. Some of the formation differs little from that of the heavier clay land, except that it is more friable and not so deep. Much of it is of the same origin as the Cecil clay—that is, it is a sediment spread over material derived from the mica schist, with which it has become intimately mixed.

The Cecil loam is a Piedmont soil. Its occurrence is confined to areas lying between the Blue Ridge Mountains and the Southwest Range. It is found in the Waynesboro and Buckingham sheets, being most extensively developed along Mechums River and its tributaries, and extending, with only a few interruptions, to the foot of the Blue Ridge Mountains. The area also reaches well up on the slopes of the foothills. The other areas are as a rule narrow and extend along slopes and uplands bordering stream courses.

The typical Cecil loam is of residual origin, being derived from the weathering of mica schists. These have weathered to great depths, as shown by sections exposed in the railroad cuts. The weathered material retains the structure of the parent rock, but upon being disturbed it falls down easily into a very fine, micaceous mass. A coarse-grained granite has also entered to some extent into the composition of this soil.

The physiographic features of this type are those of the Piedmont, i. e., rolling to hilly. The surface of the areas west of Mechums

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River is mostly composed of the sloping banks of stream valleys. The position of the land and also the ease with which water passes through it afford good drainage. In fact, the drainage is too rapid and thorough, as not enough moisture is retained to supply the needs of a growing crop, which is apt to suffer severely in times of drought.

This soil formation is very easily washed. Many of the slopes are so badly gullied that cultivation is impracticable. Even roads on the uplands are soon sunk below the general level by erosion, the action being assisted generally by the manner in which the roads are constructed and repaired.

Much of this soil is not cultivated. The steep hillsides have been gullied so that they are at present practically worthless for cultivation. Even when not gullied badly the washing has been great enough, under the methods of cultivation used, to render the land "thin." The washing can be prevented in a measure by various means, as, for instance, by cultivation along the contour of the slope, terracing, side-hill ditches, and the use of crops that will hold soil together.

Crop yields vary greatly, depending upon the manner in which the soil is managed. It requires competent management to get the best results from this soil. Of the farm crops the soil is best adapted to corn, the yield varying from 10 to 30 bushels per acre and averaging probably about 20 bushels, although yields of from 40 to 60 bushels are not uncommon on some of the improved areas at the foot of slopes, where the soil has been deepened by the wash from higher lying lands. The yield per acre of wheat will range from 5 to 8 bushels, although yields as high as 25 bushels or more are sometimes obtained on the heavier phases of the type. Grass and clover do not succeed well, except on the best areas. Formerly tobacco was grown on this soil, but its cultivation was abandoned because of soil exhaustion and scarcity of labor. Some tobacco, however, is still grown on the lower slopes and creek bottoms.

When this soil extends up the slopes of the foothills it is well adapted to fruit. The Winesap and other varieties of red apples, with the exception of the York Imperial, do well upon it. The success with fruit, however, is said to be due principally to climatic conditions. The soil is also adapted to peaches, and commercial orchards of this fruit are now established on it. In the areas of the lighter phases it is essential that the trees be given some plant food. This is done by the best growers by growing clover and applying stable manure and commercial fertilizers. There is a large area of this soil that could be used, with assurance of success, for fruit growing. The value of the Cecil loam varies from $3 to $15 per acre.

The table following gives mechanical analyses of the soil and subsoil of this soil type.

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Mechanical analyses of Cecil loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7185	1 mile W. of Ivy Depot.	Yellowish-brown loam, 0 to 9 inches.	1.85	1.94	5.10	4.80	15.32	9.58	39.56	23.60
7187	¾ mile S. of Mechum.	Brown to yellow loam, 0 to 10 inches.	2.66	1.40	3.78	2.64	6.72	8.92	52.66	23.72
7183	3 miles S. of Mechum.	Brown loose loam, 0 to 10 inches.	1.62	1.70	6.62	4.64	14.16	10.60	38.08	28.02
7186	Subsoil of 7185......	Yellowish loam to clay loam, 9 to 36 inches.	.62	3.82	4.76	3.90	14.46	9.46	31.82	32.28
7188	Subsoil of 7187......	Brown to yellow loam or clay loam, 10 to 36 inches.	.68	.80	3.02	2.10	5.68	7.80	46.38	34.18
7184	Subsoil of 7183......	Heavy brown loam or clay loam, 10 to 36 inches.	.68	2.10	5.52	3.54	10.58	7.56	36.40	34.30

CECIL SANDY LOAM.

The Cecil sandy loam is a gray, yellow, or light-brown sandy loam, with an average depth of from 12 to 14 inches, underlain by a yellow sandy loam passing through a red clay loam into stiff red clay. In some localities the sandy covering immediately overlies the stiff clay.

The Cecil sandy loam occurs in the Piedmont Plateau and in all three of the soil-survey sheets. Its greatest development, however, is on the Waynesboro sheet. The areas, broken and irregular in shape, occupy the level uplands and extend up the gentle slopes of the foothills and detached ranges to elevations rarely exceeding 800 feet above sea level.

The position of this soil on the uplands and lower mountain slopes affords good surface drainage. The more level areas, though, would probably be benefited by underdrainage.

The Cecil sandy loam is a residual soil derived from the weathering of granites and other igneous and metamorphic rocks. Near Charlottesville a variety of granulite has contributed to its formation. The sand in this area is much coarser than in the areas derived from granite, and the subsoil also contains a greater amount of sand and grades into the decomposed rock at a depth sometimes less than 36 inches.

Quartz fragments are usually present in both soil and subsoil and upon the surface. In places the soil is nothing more than a mass of

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small quartz fragments or of disintegrated granite. These areas are always thin and unproductive and allowed to remain forested.

This soil is not generally desired for general farming. It is considered poor and thin, although it is capable of easy improvement. It is largely under forest, the growth being chiefly oak, with a scattering of chestnut.

Wheat and corn are the chief crops. Wheat will yield an average of about 8 bushels per acre. Corn yields from 15 to 25 bushels per acre. Grass does not do well upon this soil, although on the improved farms good stands are often obtained. These improved farms have been brought by good management to such a high state of cultivation that fair yields of any of the crops common to the region can be obtained.

When this soil occurs on the lower slopes of foothills, it has been found to be adapted to peaches and small fruits, but so far no extensive orchards have been planted except near the railroad.

The average value of the Cecil sandy loam does not exceed $3 an acre, but improved farms near railway stations bring high prices.

The following table gives mechanical analyses of the soil and subsoil of the Cecil sandy loam:

Mechanical analyses of Cecil sandy loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7191	1¼ miles NW. of Charlottesville.	Gray to light-brown sandy loam, 0 to 12 inches.	1.20	2.32	9.80	9.62	21.94	13.06	29.76	13.50
7189	1 mile E. of Crozet..	Gray to yellowish sandy loam, 0 to 12 inches.	1.00	3.58	8.18	5.56	10.20	5.88	48.74	17.74
7192	Subsoil of 7191......	Brown sandy loam to clay loam, 12 to 36 inches.	.69	2.50	7.68	7.00	14.64	9.50	29.82	29.60
7190	Subsoil of 7189......	Red clay loam to stiff clay, 12 to 36 inches.	.57	1.62	3.10	1.86	3.78	2.94	34.66	51.76

PENN CLAY.

The soil of the Penn clay consists of a dark Indian-red to dark reddish-brown loam of varying texture, with an average depth of 8 inches. Generally it is a sticky and rather heavy loam, but often it is quite loamy. The subsoil usually consists of a red clay loam grading into

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stiff, tenacious red clay, but sometimes, when washing has taken place, the subsoil is all stiff clay and the surface may be a clay loam. In stiffness the clay is very similar to that of the Cecil clay subsoil, yet upon close examination it is found to contain a considerable proportion of fine grit. The material is derived from a fine-grained sedimentary sandstone.

The dark Indian-red color of Penn clay is a very characteristic feature, and distinguishes it easily from the other red soils of the area. Usually the surface is free from stones, but quartz fragments are found in some places upon the surface and in both soil and subsoil. Upon the higher knobs and ridges fragments of sandstone and angular fragments of coarse basal conglomerate occur, and some areas, usually too small to be shown on the map, become quite stony.

The Penn clay occurs in the Buckingham sheet as a broad belt from 3 to 4 miles wide, extending from the vicinity of Glendower southwest across the James River and into Buckingham County.

The surface of this soil is gently rolling. The map shows a difference of slightly more than 100 feet in elevation between the lowest and highest parts of the type, but this is not noticeable to the eye. The area appears more like a broad, rolling valley or plain, but really consists of a series of low ridges, with long, gentle slopes, trending to the southeast.

In the depressions between the ridges are the streams which drain the area. There are three of these large streams, each with many branches. The drainage conditions are good in general, although much of this land would be improved by underdrainage.

The Penn clay is a residual soil derived from weathering of the red Triassic sandstone and a basal conglomerate. The latter contributes the greater part of the soil material, so that the resulting soil is heavy, differing but little from the Cecil clay. The weathering has gone on to a depth exceeding 3 feet, as shown by road cuts. Only in rare instances are outcrops of the parent rocks seen. The soil does not wash badly, as the slopes are usually too gentle, but when steep enough considerable damage from washing has resulted.

There is great contrast between the Penn clay and the Hagerstown shale loam and the Penn sandy loam lying on each side. The last two types are largely forested and a distinct line of demarcation occurs, especially with the shale formation, the Penn clay being practically all cleared and under cultivation. The whole area, a great part under grass, with large, well-fenced fields and fine dwellings, barns, and outbuildings, bespeaks the fertility of the soil and the thrift and prosperity of the farmers. The general appearance of the area is much better than that of the Piedmont and more like that of the valley. The farms, as a rule, belong to a wealthy class of people, who strive to keep them in good condition.

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The Penn clay has about the same crop value as the better Piedmont soils, although it is not considered as strong a soil as the Green Mountain area of the Cecil clay. It produces, on an average, between 10 and 15 bushels of wheat per acre. Yields as high as 45 bushels per acre have been obtained. Corn yields from 30 to 60 bushels per acre. The type is a better corn than wheat land. It is an excellent soil for grass, and much of it is kept in grass, both for hay and for pasture.

The rotation commonly practiced is corn, followed by wheat, and this by timothy and clover for two or more years.

All the farmers keep a great deal of live stock, and the high state of fertility of their farms can be partly ascribed to this practice.

Up to about twenty years ago the Penn clay was extensively used in the production of tobacco, but with the decrease in the price of tobacco, the scarcity of labor, and in many cases the change in ownership of the farms, the cultivation of the crop has ceased. The soil is now used for grain and stock production. The value of this soil is about $25 per acre.

The mechanical analyses of typical samples of soil and subsoil of the Penn clay are given in the following table:

Mechanical analyses of Penn clay.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7703	2 miles E. of Esmont.	Heavy, sticky dark-red loam, 0 to 8 inches.	1.33	1.44	2.70	2.10	4.98	14.00	42.62	32.20
7705	½ mile NE. of Glendower.	Heavy dark-red loam, 0 to 8 inches.	3.28	.90	2.40	2.04	5.04	8.58	26.64	53.50
7704	Subsoil of 7703......	Dark-red clay loam to stiff clay, 8 to 36 inches.	.64	.58	1.30	.74	1.86	8.30	37.90	49.30
7706	Subsoil of 7705......	Stiff dark-red clay, 8 to 36 inches.	.99	.64	1.48	.78	2.00	4.22	20.32	70.40

PENN SANDY LOAM.

The soil of the Penn sandy loam is a yellowish to brown, or sometimes reddish, sandy loam, with an average depth of 10 inches. The subsoil varies considerably. On the higher portions it is a yellowish-red sandy loam grading into red clay loam, or stiff, tenacious red clay, but in the lower, more level situations and at the heads of streams the subsoil is a yellowish sandy loam, becoming slightly

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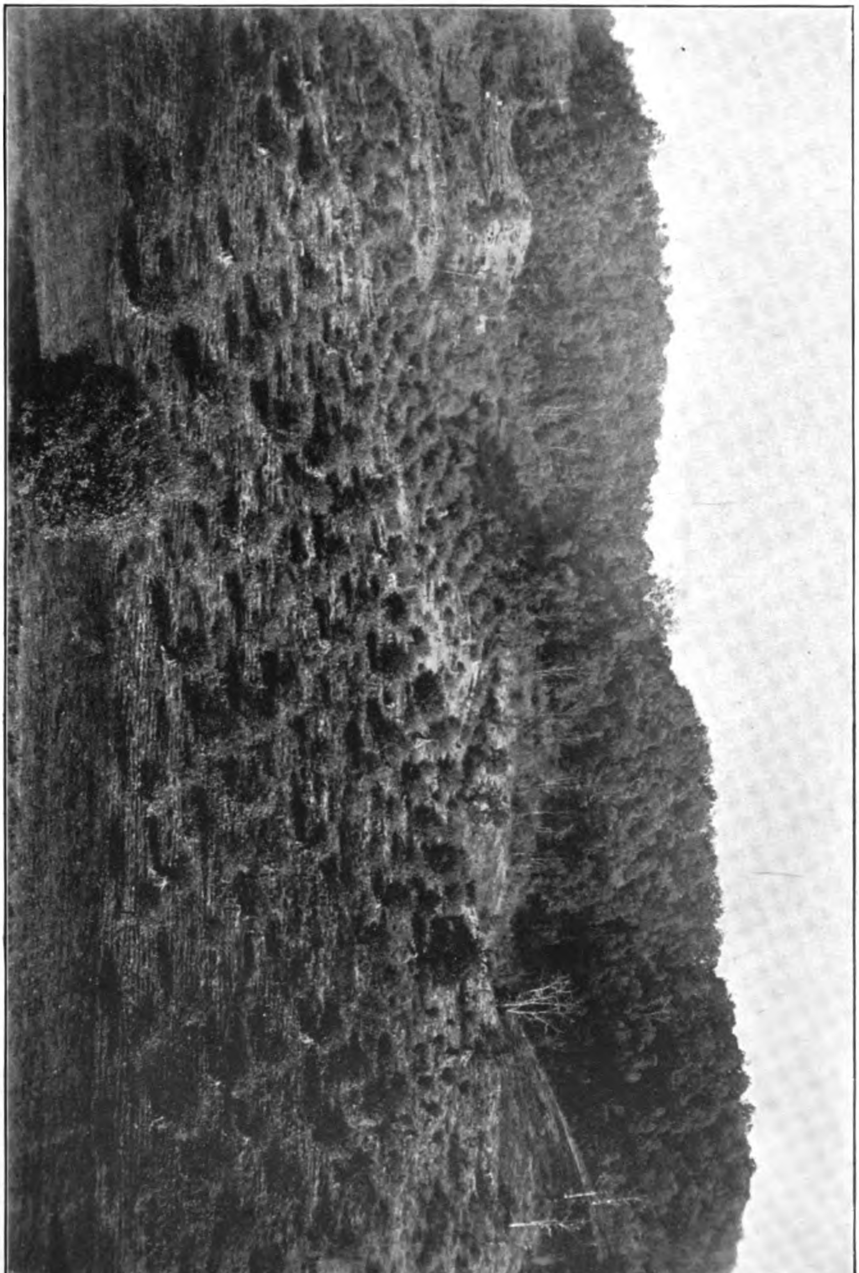

AN APPLE ORCHARD ON PORTERS BLACK LOAM, IN A SMALL COVE IN THE BLUE RIDGE, ALBEMARLE AREA, VIRGINIA.

In many of these coves the Porters black loam spreads out in a fan-shaped area, and it is such areas that are valued highly for the Albemarle Pippin.

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reddish in the lower depths, but little heavier than the surface soil. This latter phase is probably due to the washing of material from the higher parts of the areas. Fragments of sandstone and of conglomerate are found on the surface. Quartz is always found in varying quantities, occurring in both the soil and subsoil. When the proportion is large the type is spoken of as "gray land."

The Penn sandy loam occurs near the southeastern boundary of the Buckingham sheet, extending from Hatton, on the James River, northward to the Hardware River. The area is irregular in shape, having the two extremities expanded, and reaches inland from these rivers from 1 to 3 miles. At Hatton the area extends across the James River into Buckingham County.

The Penn sandy loam occupies gently rolling or nearly level uplands, which are in reality a low ridge sloping to the east and west. Fosters Creek breaks through the area between Hatton and Scottsville and empties into the James River. The former and its tributaries form the main drainage system of the area of this soil type.

The higher parts have good natural drainage, but near the heads of the streams the areas are nearly level and drainage is slow. Such areas, often called "crawfish land," are too wet for cultivation until artificially drained. At one time, before the civil war, they were drained and cultivated, but since then they have been abandoned and are now grown up with oak. Most of this phase of the soil lies between Scottsville and Hardware River.

The Penn sandy loam is a residual soil, derived from weathering of a brown or red sandstone and a basal conglomerate of Mesozoic age.

The great part of this soil is in forest, and is not so generally desired for cultivation as the other types of the locality. The higher part, having the red clay loam subsoil, is considered the best, and differs little in agricultural value from the Cecil sandy loam.

Formerly this land was all under cultivation, being the upland areas of large antebellum plantations. Then it was largely used for the production of wheat and tobacco, while corn was grown on the bottoms along the James River. At present only the better parts of the area are in cultivation. Wheat and corn are the crops, no tobacco being grown. The yields are about the same as on the Cecil sandy loam. This soil is considered good for small fruits and peaches, although at present they are not grown on a commercial scale.

The Penn sandy loam is assessed at $5 an acre.

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Mechanical analyses of typical samples of this soil are given in the following table:

Mechanical analyses of Penn sandy loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7709	2 miles E. of Glendower.	Yellowish sandy loam, 0 to 8 inches.	1.73	1.90	6.92	5.74	11.16	8.72	53.28	12.14
7707	1½ miles NW. of Hatton.	Yellow sandy loam, 0 to 10 inches.....	1.12	4.20	7.04	4.44	7.50	13.04	39.16	23.96
7710	Subsoil of 7709......	Yellow sandy loam, 8 to 36 inches.	.76	1.98	5.72	5.04	9.60	8.68	50.18	18.66
7708	Subsoil of 7707......	Yellowish-red sandy or clay loam, 10 to 36 inches.	.67	1.58	4.94	2.54	4.88	6.46	35.34	44.26

CONOWINGO CLAY.

The surface soil of the Conowingo clay varies from a yellowish to brown or reddish loam to a reddish-brown clay loam with an average depth of 8 inches. It is more or less micaceous, and upon the surface there are usually fragments of the parent rocks. The quantity of rock fragments rarely exceeds 25 per cent. The subsoil is a yellowish-red to red clay loam, sometimes becoming quite stiff clay. Usually in the lower depths the subsoil becomes lighter, containing decomposed fragments of soapstone, which give it a greasy feel. The subsoil also is micaceous.

This soil occurs as a continuous strip in that part of the Piedmont Plateau lying within the Buckingham sheet. It is contiguous to the western boundary of the Conowingo Barrens and has about the same extent as the latter soil type.

The topography is that of the rolling Piedmont, the area occupying a ridge parallel to that covered by the Conowingo Barrens. The configuration of the surface affords good drainage and there are few, if any, local areas requiring artificial drains.

The Conowingo clay is derived from the weathering of steatite and other metamorphic rocks, which were probably originally the same as the schist to which the Cecil clay of the Green Mountain section owes its origin. Large quantities of soapstone are quarried at Alberene, in Albemarle County, and at Schuyler, in Nelson County, both of which places are located in the Conowingo clay area.

In Maryland this soil is known as "productive serpentine land." In

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this area it differs but little from the Cecil loam or even the Cecil clay. In productiveness it is equal to or even better than much of the Cecil loam, is readily improved, and when brought to a high state of cultivation is easily kept there. It is esteemed a good corn soil, yielding 20 bushels or more per acre. The yield of wheat will probably not average over 8 bushels, while the grasses and clover do fairly well upon most of the areas. Because of the occurrence of soapstone beds beneath this soil the land is held at a higher value than it is really worth for agricultural purposes.

Mechanical analyses of the soil and subsoil are given in the following table:

Mechanical analyses of Conowingo clay.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7694	¾ mile NE. of Alberene.	Reddish loam, 0 to 8 inches.	0.87	1.14	3.86	3.74	16.84	21.72	26.92	24.94
7695	Subsoil of 7694......	Red clay loam, 8 to 36 inches.	.55	.34	1.38	1.84	9.90	10.86	32.46	42.86

CONOWINGO BARRENS.

The soil of the Conowingo Barrens is a rather coarse sandy loam from a few inches to 18 inches in depth. The color varies greatly. Usually it is gray to yellowish, but in the level swampy areas it is greenish yellow or, in some cases, blackish. There may be practically no subsoil at all, the shallow sandy covering resting upon a mass of broken rock, or sometimes there is no soil covering whatever. In the level areas the subsoil is a dirty yellowish color, the texture grading from a sandy loam to clay loam, or it may be a stiff, waxy, impervious yellow clay. The latter phase prevails where swampy conditions are found. Such areas are called "glade land."

Rock fragments and rounded stones, called "niggerheads," are scattered over the surface. There are also large bowlders and outcrops of a greenish metamorphic rock. Generally these rocks and outcrops are in sufficient quantity to render the land untillable even if other conditions warranted its cultivation.

This soil occurs only on the Buckingham sheet in the Piedmont Plateau. It occurs as a continuous strip from one-fourth to 1 mile wide, occupying a ridge extending from the northeast corner of the

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sheet southwest through the area. The soil is derived from the weathering of serpentine and similar altered rocks in place.

The land is worthless for agricultural purposes, being quite unproductive. This is said to be due mainly to excess of magnesia in the soil, and probably its droughty nature also has some influence in its sterility. Water passes quickly through the soil and the fragments of rock forming its base. None of this soil is cultivated. It supports a forest growth consisting mainly of dwarf oaks. Some of the trees on it, however, reach a fair size. The only dwellings seen on the type are the cabins of negroes, who till the contiguous productive lands.

MEADOW.

The term Meadow has been applied to a class of soils of sedimentary origin, occurring along the larger stream bottoms. These soils are a heterogeneous mixture, depending upon the material forming the adjacent slopes and that brought down by the streams at times of high water. The soils vary in texture from very sandy to silty.

The greatest development of Meadow is in the valley, along the Shenandoah River and its North, Middle, and South forks and their tributaries. Along all these streams, except Middle River and its tributaries, the sediment is more or less sandy, having been brought down from mountains composed of sandstone. This sand, mixed with the wash from the limestone soils of the valley, makes a very fertile soil. Middle River and its tributaries flow through a shale formation and the sediment from this is a silty loam, only occasionally becoming sandy.

In the Piedmont section the Meadow is not important. There the streams are cutting their channels and not building up flood plains, and the Meadow areas are, therefore, not extensive.

In general the Meadow lands are wet and poorly drained and are frequently inundated. Consequently they are best adapted to grazing and in the valley are generally put to this use. Along the larger bottoms and back from the stream banks, where only the highest waters reach, wheat and corn are grown. The soil and moisture conditions are best adapted to corn, which yields often as high as 100 bushels an acre. Wheat makes too rank a growth, and during the winter season there is always the liability of the fields being flooded. These bottom lands also produce good melons, and near the larger towns this crop is grown on a commercial scale. In the Piedmont plateau these bottoms, where the sediment has been derived mostly from the Cecil clay, are used principally for wheat and dark shipping tobacco. Corn is also one of the crops grown. As a general thing the value of this Meadow greatly exceeds that of the upland soils.

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FRUIT GROWING.

Fruit growing has become an important part of the agriculture of the Albemarle area. From the time of its early settlement it had been regarded as a good fruit country, judging from the great profusion and excellence of the wild grapes, and, later, from the quality of fruit and productiveness of isolated fruit trees planted around the houses. The development of fruit growing as an industry was, however, slow, and not until recently has it become of importance. The Twelfth Census estimated that there were in 1900 about 1,000,000 apple trees and about 200,000 peach trees in the counties represented by the survey. This number is probably much exceeded now, as a great many trees have been planted in the last two years, especially in the valley section.

The principal development of the fruit industry has been in the southern part of Albemarle County, extending over into Nelson County. The orchards of this section probably comprise about 800,000 apple and over 100,000 peach trees of bearing age.

The fruit interest east of the Blue Ridge is developed principally in two sections. One occupies the lower eastern slope of the Blue Ridge from near Crozet to Humpback Mountain, with only a few scattered young orchards beyond these points. The other and larger development is in the Ragged Mountain section, where the orchards are mostly in the coves of those mountains. In this section the largest orchards, mostly apple, lie around Covesville, this being the point of largest shipment of apples from Albemarle County. There are also orchards scattered throughout the Plateau proper.

In the valley the planting of orchards has been general, especially on the lighter soils. The orchards now bearing are peaches, the apples being set out only recently. The largest bearing apple orchards are on the Hagerstown loam in Augusta County, in the southern part of the Waynesboro sheet.

The favorable climatic conditions and the number of soils adapted to the different varieties of fruits makes this an area peculiarly adapted to successful fruit growing. The Blue Ridge Mountains shelter the section to the east of them from the cold winds of the interior. The elevation is also a great factor, as it affords good water and air drainage, thus lessening the liability to frosts. As mentioned before, there is a zone or belt on the slopes, the lower limit of which is from 900 to 1,000 feet above sea level, that is not subject to killing frosts during the growing season. For successful fruit growing by far the best location for an orchard is within this frostless belt, or "green belt," as it is locally called. This fact has been recognized, and most of the orchards are planted within this zone. The best elevation may be regarded as between 1,200 and 1,500 feet. It is at this height that the

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best quality of fruit is produced. Elevations above 2,000 feet are, as a rule, subject to sleet and hail storms and heavy snows, which damage the trees. The strong winds that prevail at higher elevations would also do much damage to fruit. The fogs are another factor to be considered. Where they are prevalent the moisture conditions are favorable for fungous diseases. For an apple like the pippin this is quite serious, as any cloudiness or imperfection of the skin affects its sale. The higher and the lower situations are both subject to fogs. Often the mountain tops are enveloped in clouds and the lowlands hid by fogs, while between them on the slope it is clear. This clear portion corresponds approximately to the "green belt." At the lower elevations the moisture conditions of the soil may also be unfavorable, because of poor drainage. In the lower situations the fruits "smut," this being especially true of the pippin. The quality of fruit in general is said to be better at a medium elevation than at either extreme.

Some preference is given to slope. For varieties like the red apples and peaches a sunny location is desired, while for the pippin a northeast exposure, getting the morning sun, is desired.

With but few exceptions all the soils are more or less adapted to fruit growing. There are types, however, that are particularly well adapted to certain kinds and varieties of fruits. Until recently planting was done without regard to location or adaptability of soil to the different varieties, but now the growers recognize the adaptation. Instead of an orchard being a solid block of a particular variety, it will be found to be made up of several varieties planted in places suited to each.

The varieties of apples principally grown are the Newtown Pippin (here known as Albemarle Pippin), Winesap, York Imperial, Pilot, Ben Davis, Baldwin, and a few others. The leading varieties of peaches are the Belyeu Comet, Elberta, Crawford, and a large number of others of less prominence. The leading variety of grape, and the one most resistant to diseases, is Norton's Virginia Seedling, with Concord, Ives, Catawba, and Delaware ranking in the order named.

It is the apple, and particularly the Newtown Pippin, that has brought this section into prominence. This apple is exceedingly variable and susceptible to influences of soil, climate, and elevation. Under the favorable conditions existing in this section it has reached a high degree of perfection and has become known as the Albemarle Pippin. It has been considered as a distinct variety of local origin. This, however, is doubted, as the most authentic account of its introduction states that it originated from cuttings brought in from Pennsylvania by Dr. Thomas Walker, a surgeon of the Virginia troops with Braddock at the time of his defeat, on his return home in 1755. These cuttings were used for grafting trees upon his estate in Albemarle County. The original seedling tree of the pippin is said to have been

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grown at Newtown, Long Island. It is not mentioned whether it was the green or yellow variety. The green, however, is considered a variation of the yellow. Both are grown here, but the yellow is considered the better and is more extensively grown.

The soil particularly adapted to the pippin is the Porters black loam, where it occurs in sheltered mountain coves. Here the soil is rich, mellow, and deep—all essential to the growth and productiveness of this variety. The pippin is at first of slow and slender growth, and requires from fifteen to twenty years before it comes into full bearing. It will not grow thriftily on a heavy soil. Pippins are grown on the more loamy phases of the Porters sand and Porters clay and a fine quality of fruit is produced on these soils. There is some difference of opinion as to where the pippin will grow. Some claim that all that is necessary for its growth is elevation and proper care. It is true that fine fruit is grown on the soils last mentioned, but the yields are uncertain, while on the Porters black loam (pippin land) a crop is assured every fruit year and with very little care. If grown on the poorer soils, they must be fertilized heavily and be given the best of cultivation. (See Pls. VI and VII.)

Until recently the pippin has been a very profitable fruit, but with the advent or increase of insect pests and fungous diseases it has not been so profitable. The bitter rot causes most of the injury and is very difficult to control, though it can be done. Lately the twig blight has done much injury to the trees. Insect pests are increasing, so that now there is a tendency to grow varieties that are not so easily injured. The long time before the trees begin bearing is also a factor against the pippin. It is considered now, since the increased difficulty of producing perfect pippins, more profitable to grow varieties that come into bearing sooner, even though they do not bear as long. When pippins are planted now it is found to be a good plan to plant peach trees alternately with them, thus getting some return from the land while the pippin trees are growing. After beginning to bear they yield heavily every other year, and the best growers claim that they can be made to bear enough the "off" year to pay expenses. It is very desirable to get first-grade fruit, as the best grade is exported and brings much higher prices than at home. The pippin brings from $1 to $2 more per barrel in the orchard than other varieties.

The red varieties of winter apples grow and do well on a greater variety of soils and are not so limited as to position. They are of rapid growth, begin to bear within seven years of planting, and bear heavily in "fruit years." In "off years" as much as 50 per cent of a crop can be expected if the trees are given proper treatment. The Winesap is the principal and most profitable of the red varieties. This variety is particularly well adapted to Virginia. It does well on the loamy and also the heavier soils at the lower as well as at the higher elevations. It does well in the mountain coves, providing they are open

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enough to admit sufficient sunshine to develop the color. It also succeeds well on the Porters clay and upon the Piedmont soils and locations, as well as on all the fruit soils in the valley.

The York Imperial does best in the valley, and especially upon the Hagerstown loam. On the eastern side of the Blue Ridge it ripens too early and falls and does not have as good keeping qualities. The keeping qualities have been found to be improved by applications of lime to the land. In the valley this variety is a thrifty grower and gives large yields. The fruit is large and has a fine color and flavor. It is a heavier bearer than the Winesap, and the prices obtained are about the same. The York Imperial is a good shipper and is gaining favor in the export trade. The other red varieties are not extensively grown, but probably do best in the valley.

Peaches are grown upon the lighter soils and higher elevations in the valley, on the mountain soils, and on the lighter soils of the Piedmont, in favorable locations. The Elberta is considered the best of all the varieties, though others also do well. To the mountains the Belyeu Comet is best adapted and the most profitable to grow. It is the latest variety to ripen. It is large, has a fine color and flavor, and above all is an excellent shipper. It is now being used to develop the export trade.

Strawberries do well upon the sandy soils where peaches grow, and upon the bottom lands. They are usually planted between the rows of peach trees. Wild blackberries are abundant, grow to large size, and are of good quality. None of the cultivated varieties are grown.

In general, the orchards are not cultivated as well as they should be. The practice has been to let the trees take care of themselves. The better growers, however, fertilize the orchards, and by them it has been found a good practice to grow cowpeas or clover between the trees. These crops are sometimes turned under for green manure, but in most cases the clover is cut up with a disk harrow in the spring, which does not destroy the clover roots. The clover continues to grow, producing enough seed to reseed the land, and by fall forms a good covering to go through the winter. Spraying is not generally practiced. Insect pests and fungous diseases are increasing, and it is absolutely necessary to spray in order to get perfect fruit and large yields. Those growers who spray thoroughly throughout the season are securing the best returns.

Spraying, however, is difficult and expensive on the mountain slopes, and especially so if the orchards are situated above the water supply, making it necessary to carry the water uphill.

Considering the cost and difficulty of cultivation, spraying, and harvesting of fruit on mountain slopes, it seems that fruit growing would prove more profitable on the more level and tillable lands of the Piedmont Valley, although the climatic conditions are not so favorable.

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Markets are found for the fruit in the large Southern and Northern cities along the coast. Richmond, Baltimore, and New York are the principal centers to which the fruit is sent. Here it is placed in cold storage and distributed from time to time to meet the demand. Very few of the growers market their product direct. The practice is to sell the crop in the orchard. It seems that as the industry develops it would be much better for the growers of this section to combine and have a cold-storage warehouse at a convenient place in the area. The product would warrant it, as in 1899 the total number of barrels shipped on railroads from the counties in this area exceeded 50,000.

The export trade is increasing rapidly as the facilities for handling become better. Practically all the first-grade pippins are sent to England, where they net higher prices than can be obtained here. The export trade from this area was begun with the pippin in the first year of Queen Victoria's reign, when Mr. Stevenson, our minister to England, who was a resident of Albemarle County, presented the Queen with several barrels of pippins. She was so pleased with the flavor and excellence of the fruit that in acknowledgment she had the small import duty on this apple removed. From that time on the export trade has gradually grown. Now the red varieties are coming into favor and are being exported in large quantities. The poorer grades of apples are made into cider, of which a considerable quantity is manufactured. Large quantities of apple and peach brandy are also made.

Many attempts have been made to develop the grape industry in this area and on adjoining soils to the east. The abundance and excellence of the wild grapes found growing here at the time of settlement led the people to believe that this was a grape section, so that the first attempts in fruit growing were in the culture of grapes. These attempts proved to be failures because in every case it was attempted to grow the grapes of Europe, which could not succeed here. It was not until the native grape was used as stock that success was attained. It was in 1867 that the industry really began, and by 1873 the growers, finding it hard to compete in the market with Northern growers, combined and formed a company, built a cellar, and began wine making. This is said to be successful and is still continued. At present the product is from 35,000 to 60,000 gallons annually. The wines have become well known and have a ready sale. At one time there were 1,200 acres in vineyards, but the acreage has now fallen to about one-third that number. The existing vineyards are doing well and the growers receive good returns. The decline has been due to lack of knowledge in cultural methods and in combating insect pests and fungous diseases. Black rot has caused the most injury. The successful growers obtain yields of from 1½ to 4 tons per acre. The prices paid vary from 2 cents per pound for the Concord to 5 cents for the Delaware. The variety which is most profitable is Norton's

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Virginia seedling, which is more resistant to attacks of fungous diseases. It does not bear so heavily as the Concord, but makes a superior wine.

The grapes are grown on the "Green Mountain land" (Cecil clay) and its more loamy phases. The eastern slopes of the hills are the best situations. The "mixed slate land" also produces good grapes. It is claimed that all the country lying between the Southwest Mountains and Blue Ridge is adapted to grape culture.

AGRICULTURAL CONDITIONS.

The Albemarle area is one of the most important agricultural sections of the State. The three different physiographic divisions afford a variety of soils more or less fertile and adapted to a variety of crops, admitting of a diversified system of agriculture. In the valley the agriculture was formerly devoted entirely to the production of grain, grasses, and live stock, while in the Piedmont it consisted of general farming, with tobacco as the money crop. Recently there has been a tendency toward greater diversification and the recognition of adaptation of soils to crops. Fruit growing has now become an important factor in the agriculture of the area. The development of this industry is taking place throughout the area wherever soils and conditions are favorable. As a whole, the farming class is prosperous and conditions, though diverse, are everywhere improving.

The Valley of Virginia has always been recognized as the most prosperous section of the State. This applies as well to the part of the valley included in this area, Augusta and Rockingham counties being among the wealthiest and most prosperous counties of this State. This prosperity has been due mostly to the natural fertility of its soils and the thriftiness of its people. Never depending entirely upon inefficient slave labor, they worked their farms themselves and still continue to do so. Very little renting is done, the owners living upon the farms and hiring the labor necessary. Labor is scarce, but is efficient. The negro population is small. The condition of the valley farmers is shown by the appearance of their farms. Usually there is a pretentious dwelling, with one or more large barns and the necessary outbuildings, all kept neatly painted and in good repair. The old-fashioned rail fences have mostly been removed and replaced by smooth-wire fences, the posts and stays of which are usually painted. The lack of forests and the wire fences give the valley farms an open and pleasing appearance.

The farms rarely exceed 400 acres in extent. The average is about 200 or 250 acres in this area, but according to the U. S. Census for 1900 the size of the farms in Augusta and Rockingham counties averages 145 and 105 acres, respectively. The size of the farms is decreasing. For the State the percentage of increase in number of farms in the past ten years has been 31.6. The increase here mostly

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takes place upon the division of estates to children, as few of the valley farms are for sale. Land values are high, having increased very rapidly since the planting of orchards. The poorest lands, which brought only about $10 an acre and were not in demand even at that price, now bring more than double that amount. Heavier lands in good locations near towns and railroads bring as high as $100 or even more an acre.

Improved machinery is used upon all the valley farms. The lack of labor and the smooth contour of the valley ridges have assisted much in bringing this about.

The growing of cereals and grasses and the raising of live stock are now, as in former years, the principal industries, except where fruit can be grown. More live stock is now being raised, the acreage of wheat is being cut down, and more land is put in grass. The live stock consists mostly of cattle of improved breeds. The horses are mostly of the heavy draft breeds. The largest stock raisers own mountain pasture lands, where the cattle are pastured during the summer, being returned to the valley farm for the winter and there fattened upon the products of the farm. Large quantities of manure are made and applied to the land, maintaining the fertility and allowing the farmers to get their lands into a high state of cultivation. These farmers have made money.

There are many farmers who do not keep much live stock, but who raise hay for the market. The hay is baled on the farm and shipped out of the area. At present prices this is not very remunerative, and the practice will in time remove much fertility from the farms and should be discouraged.

The fruit industry has a promising outlook, affording a diversification of crops and profitable remuneration as well, especially on the poorer shale and gravel lands.

The roads are all good and kept in good repair. The principal roads are macadamized. The valley pike passes through this part of the valley.

Much of the mountain area is of little value except for its chestnut and oak timber. Large quantities of tan bark are taken out annually to supply the home tanneries and for shipment. There are large quantities of timber, but much of it is so inaccessible that it can never be obtained except with great difficulty and expense. The lands so located as to be adapted to pasturage or fruit are in demand and bring fair prices. The coolness and absence of flies in the higher elevations make them desirable locations for pasturing stock. The blue-grass pastures produce so good a quality of beef that much of it is sent into the export trade. The fruit produced on the lower eastern slopes and foothills is of high quality and commands a ready market.

The Piedmont section of the area surveyed represents one of the

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most prosperous portions of Piedmont Virginia. Albemarle County ranks high in its agricultural wealth and resources.

Improvements on farms are being made slowly, as the people have lacked capital to make them heretofore. Usually there is a good dwelling house on every farm, but the outbuildings are either lacking or else small and poorly constructed and do not afford good shelter for the live stock kept, nor storage room for the crops harvested or the machinery used in cultivation. The farms are as a rule not well fenced.

The farms in the Piedmont section are all large, comprising usually more than 300 acres. There are a number over 500 and even 1,000 acres or more in extent. These are much too large to be worked economically under present conditions, and in consequence only the better parts are cultivated, while the remainder is left uncultivated and allowed to wash and gully. The owners as a rule live upon their farms, working all the land they can with the labor that can be hired, and letting out other tracts to tenants who rent on shares. The labor is scarce and is inefficient. The negroes, who were depended upon for labor, have been attracted by the seemingly higher wages paid on public works and have consequently left the farms. No inducement in the way of an increase of wages has been offered them by the farmers in order to hold them. Most of this labor, however, is inefficient, and especially is this true of the younger element. The negroes have but few wants and, as a rule, work no more than is necessary to supply them.

By the improvident use of the land prior to the civil war all the area had been cleared and put under cultivation at one time or another, so that now very little of the original forest remains. The forest now found is second growth and probably occupies nearly one-half of the area surveyed. It would probably be best to let most of this forest remain, especially on the slopes. A good system of forestry would no doubt bring to the owners in time better returns than would be obtained by putting these lands under cultivation again. The production of chestnuts could be increased and be made remunerative, especially if successful means can be found for combating insect pests.

The problem of preventing the washing and gullying of slopes confronts the farmers of to-day, as it did those of earlier times. In general there is no attempt toward prevention of washing or the reclamation of washed lands. There are a few instances, one being in the vicinity of Covesville, where washing has been successfully prevented by terracing. Following the contour of the slope in cultivation is generally practiced, but as a rule no other means of prevention are added to this. The use of cover crops on the land at seasons when it would otherwise be bare would do much to protect it. Forest growth, which soon appears, is depended upon to save abandoned fields.

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Formerly tobacco was the sole money crop, but later, as a result of the lack of capital, the scarcity of labor, the impoverished condition of the soil, and low prices for tobacco, the growing of this crop was practically discontinued. It is still grown to some extent, but only in limited areas on the best of soils. In these sections it is still found to be profitable. Hat Creek bottoms in Nelson County are well known for the fine quality of tobacco produced. Much of it grades as a fine black wrapper and brings high prices, proving quite profitable. Other tobacco sections are found along Ivy and Beaver Dam creeks.

In general only the more level uplands and the creek bottoms are in cultivation. Upon these are grown the general farm crops, wheat and corn being the principal ones. The most of the corn is grown on the creek bottoms and is only grown on the uplands to prepare for wheat. A systematic rotation is not generally practiced, but where it is grasses and clover are included with wheat and corn. Clover and grass do well where proper attention is given to seeding and care of the fields. The growing of cowpeas and other leguminous crops for green manure is practiced by but few. Little live stock is kept and no efforts are made to save and use the barnyard manure. The main dependence is upon commercial fertilizers, of which large quantities are used for all crops.

A great deal of the Piedmont section could be used to advantage for pasturage, especially the slopes where cultivation is difficult and washing severe. The grasses will grow, as is evidenced by a few farms where the attempt has been made. The grass covering would prevent washing, and by pasturing stock on these fields their fertility could be in a measure regained. Goats, in one instance, have been found profitable, and proved of great service in clearing out the underbrush in woods. Sheep would doubtless prove profitable, and would keep down the underbrush and keep the fields clear of "foul" growth. The small mountains are admirably suited for pasturing sheep.

Much interest is taken in the breeding of horses. There are several large breeding farms owned by Englishmen. Attention is mainly given to the raising of coach horses and hunters. This interest is kept up by annual horse shows, at which these horses are shown with horses of like type from different sections of the United States.

The value of farms varies greatly, depending largely upon nearness to railroads and towns. The general price is from $10 to $15 an acre. Farms remote from railroads bring less than this, while desirable farms in the vicinity of Charlottesville and neighboring towns bring from $50 to $100 an acre. These latter prices are sometimes due in part to the historical interest attached to the old estates, and also to the healthful climate and beautiful surroundings. These estates, usually consisting of not less than 300 acres, are bought by wealthy business and professional men of the large Northern cities, who build

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upon some prominent hill a fine residence, in some instances costing as high as $50,000. They also spend large amounts in other improvements, and consequently do much toward beautifying their immediate section of the country.

With the exception of the northern part of the Piedmont section the transportation facilities in the area are good. Two railroads traverse the valley, affording good shipping facilities to the Northern cities, while in the Piedmont the Southern Railway passes through the fruit section in the Ragged Mountains, affording direct connection with Northern and Southern points. The Chesapeake and Ohio Railway crosses the area east and west, affording direct connection with Washington and the Northern cities, while to the west it passes through the mining region of West Virginia, which is the best market for the small fruits and garden produce of the area.

The greatest hindrance to development of any kind in the Piedmont section are the poor roads. Not until good roads are afforded can the more remote sections be developed.

Harrisonburg is the only city within the area. The two cities of Staunton and Charlottesville lie immediately outside of the area. These are all thriving railroad, commercial, and educational centers. There are besides many small thriving towns scattered over the area.

The beautiful mountain scenery, healthful climate, and great variety of mineral waters of more or less medicinal value attract to the region annually large numbers of tourists, who support many summer and health resorts.

The writer wishes to acknowledge his indebtedness to Prof. William A. Taylor, Division of Pomology, Bureau of Plant Industry, U. S. Department of Agriculture, for information regarding the history of the introduction of fruit into the section of Virginia within which this survey lies.

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SOIL SURVEY OF THE HICKORY AREA, NORTH CAROLINA.

By THOMAS A. CAINE.

LOCATION AND BOUNDARIES OF THE AREA.

The Hickory area is located mostly in the Piedmont section of western North Carolina. A part of the Brushy Mountains is included in the northwestern corner of the area. The area is rectangular, containing about 988 square miles, or 632,128 acres. It includes parts of Catawba, Lincoln, Burke, Caldwell, Alexander, and Iredell counties. It is bounded on the north by parallel 36° and on the south by parallel 35° 30′ north latitude, and on the east by meridian 81° and on the west by meridian 81° 30′ west longitude. Within the area there is a range in elevation of 1,730 feet.

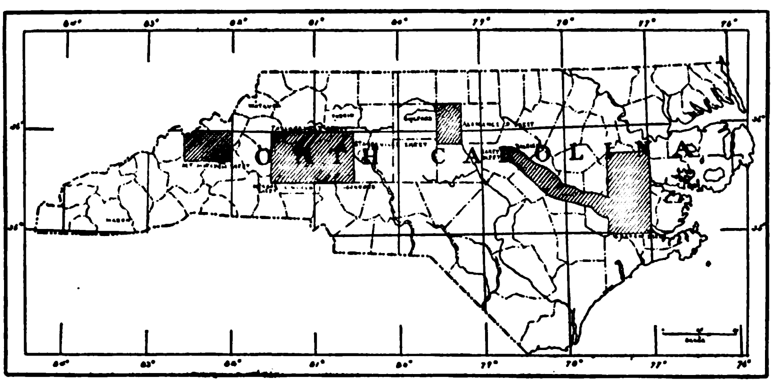

Fig. 5.—Sketch map showing areas surveyed in North Carolina.

Hickory, population 2,535, is the largest town in the area. Newton, county seat of Catawba, is next in size, having a population of more than 1,500. Maiden and Catawba are small but important villages. All these towns are situated on the Western North Carolina Railroad. In the southern part of the area the largest town is Taylorsville, with a population of 413. This place is upon the Charlotte and Taylorsville Railroad.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Early in the eighteenth century a number of Scotch, who had formerly settled in the north of Ireland, emigrated into New Jersey and

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Pennsylvania, and later, coming through Maryland and Virginia, settled in North Carolina. A few came direct from Scotland, but the majority, coming from Ireland, were known as Scotch-Irish. Along with these Scotch-Irish, and settling in the same territory, came the Germans, who also moved south from Pennsylvania and were known as Pennsylvania Dutch. These two nationalities established colonies in Catawba and Lincoln counties, where rich lands could be secured cheaply and without difficulty. The country south of the great bend of the Catawba River was first settled.

The settlers found the country inhabited by the Catawba Indians, with whom they made a treaty of peace. These Indians lived chiefly on the game which abounded in the forests, tilling only small patches of ground. The timber had been removed from these fields by burning, and the planting and cultivating of the crops were done by the squaws.

As the news of the cheap lands, fertile soils, and mild climate was taken back to Pennsylvania, other settlers followed and the region north of the Catawba River was gradually taken up, in spite of the hostility of the Cherokees. In a few years the country south of the Catawba was transformed into a populous community. The bottom lands along the river were the first to be taken up. They were covered by a dense growth of cane, but by burning and draining were more easily cleared and planted than the uplands, covered by forests of oak and hickory. Later, as the population increased, these forests were cleared off. The Dutch settlers wisely chose the stiff red clay lands rather than the sandy soils. These red clay farms are still considered the most valuable farms in the area and in many cases they have not changed hands, but are still owned by the descendants of the original settlers. The red clay soils were soon found to be especially adapted to grain. Their value increased with the increase of population, and as the introduction of more and better agricultural implements increased their production. In the beginning of the nineteenth century the discovery of rich ore beds, the erection of furnaces, and the extraction of iron caused settlement to progress rapidly, and with the increase of the population more lands were brought under cultivation to supply the increasing demands for farm produce.

The character of the first settlers is in no small degree responsible for the great success they have made in agriculture. They were a brave, industrious, law-abiding people. They bought very little and sold much of their farm products. They contracted no debts they were not able to meet. None of them were large slave owners, none were very poor, and none very rich; all were on an equality. These people have changed comparatively little in recent years. The descendants of the Scotch-Irish and Pennsylvania Dutch still own the greater part of the land in the area. Their farms are free from mort-

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gages, and they are satisfied to remain at home instead of abandoning the farms to work in the many factories that have been built along the Catawba River in recent years.

In 1870 cotton was introduced into this section of the State and soon became one of the money crops. A few years later tobacco was introduced and large areas of the sandy soil were cultivated to that crop, but at present very little is grown. The larger part of the area is still devoted to corn and wheat, and cotton is also one of the principal crops. The construction of railroads through the area has greatly aided its agricultural advancement, being an especially important factor in building up the fruit industry of the mountains. Thus the Hickory area includes some of the best farms in the State.

PHYSIOGRAPHY AND GEOLOGY.

The area lies almost wholly within the Piedmont Plateau, but is crossed by the Brushy Mountains in the northwest corner. It extends to the range of sharp knobs and ridges that runs from Kings Mountain to Anderson Mountain. The altitude ranges from about 700 feet, where the Catawba River leaves the area, to 2,430 feet at Coxs Knob, in the Brushy Mountains.

The Brushy Mountains form the drainage divide between the Yadkin and Catawba river systems. The streams on the north side flow into the Yadkin, while those south of the mountains empty into the Catawba; but all the water finally reaches the Atlantic. Many of these mountains can be cultivated to the top, but on many others the steeper sides are merely great expanses of bare rock. Where the timber has been cut off the erosion is very rapid, a great part of the soil being washed down into the streams. In the mountain area there are many small, rapid-flowing streams. In the valleys these streams seem to have been cutting their channels deeper in recent years, so that they now furnish a natural drainage for some of the lower lands where water from the surrounding mountains formerly collected and made them too wet for cultivation. The rocks from which these mountain soils are formed consist of granite, gneiss, and schists. They lie very near the surface, often outcropping in masses or in various degrees of disintegration.

The Catawba River flows through the center of the area from west to east. It is a rapid stream, having a considerable fall within the area. This river, together with the Little Catawba, drains the whole of the area south of the Brushy Mountains and furnishes some of the best water power in the State.

The Piedmont Plateau south of the Brushy Mountains presents a gently rolling appearance, with a few isolated peaks along the southeastern and western borders of these mountains. It is intersected by numerous small streams which flow through valleys of level bottom

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lands. These bottoms are often narrow and are frequently flooded by the overflow of the streams, whose channels seem to be gradually filling up with material washed down from the hills.

The soils of the plateau are usually deep, and the parent rock is seen only in road cuts or stream beds. These rocks are mainly mica schists, granites, and gneisses, belonging to the Laurentian system. The schists are found on the ridges and higher swells and do not reach down to the level of the river channels, so they overlie the gneisses. These rocks extend across Alexander and Caldwell counties to the Brushy Mountains, becoming coarser grained to the westward. In some places the coarse nodules of quartz and feldspar have the appearance of a conglomerate. East of Newton the rocks appear less micaceous, and syenite and other hornblendic rocks are more abundant. Westward, toward Hickory, mica schists are found which weather into a soft brown material. They can be easily cut, being in many respects like soapstone. Garnet crystals occur abundantly in many of the rocks, but are so imperfect and altered by weathering that they have no commercial value.

The southeastern part of the area lies within what is known as the Kings Mountain belt. This is a narrow belt, composed of quartzites, clay slates, and mica schists, which extends from Kings Mountains northeast to the Catawba River. These rocks are thought to belong to the Huronian system. Beds of limestone occur frequently in this belt, the largest deposit being a few miles north of Anderson Mountain. Many varieties of minerals occur in this section, but the only one of commercial value is iron. There are a number of beds of magnetic iron ore in the vicinity of Anderson Mountain. The thickness of these beds is from 4 to 12 feet, and the ore is very rich in iron. Brown hematite ore is also found here in large quantities. Until recently these deposits were worked. The furnaces were built near the mines and flux was obtained from the limestone deposits near by. The abandonment of these mines was not due to the lack of ore or to a poor grade of ore, but to the distance from the railroads, the difficulty of getting the product to a market, and to the lack of capital. The mining done here has always been on a small scale. It has been carried on at intervals for a period of a hundred years or more.

Gold has been found in small quantities in several parts of the area, but not in sufficient quantity to be mined profitably. The Shuford mine, near Catawba Station, has been worked at different times for many years, gold being found in both the soil above the rock and in the rock itself. Only one gold mine is now in operation in the area. This lies about 4 miles east of Newton. In this mine small amounts of gold are obtained from the underlying rock. Mica and monazite have both been mined in the area, but not extensively. The mona-

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zite is found in the stream beds, and is obtained by shoveling and washing the gravel deposits.

The stiff pipe clay found on the Little Catawba River is extensively used in the making of earthenware vessels, and this industry has grown up rapidly in the southern part of the area.

SOILS.

In all ten different types of soil were recognized in the Hickory area. The following table shows the extent of each of these types and the proportion which each is of the whole area surveyed:

Areas of different soils.

Soil.	Taylorsville sheet.	Hickory sheet.	Total area.	Proportional extent.
	Acres.	*Acres.*	*Acres.*	*Per cent.*
Cecil sandy loam	149,120	206,848	355,968	56.4
Cecil clay	33,920	86,784	120,704	19.1
Porters sandy loam	49,792	128	49,920	7.8
Conowingo clay	29,952	....	29,952	4.6
Porters stony loam	22,528	2,624	25,152	4.0
Meadow	9,536	14,336	23,872	3.8
Porters sand	11,136	....	11,136	1.8
Porters clay	7,552	....	7,552	1.2
Durham sandy loam	1,344	6,016	7,360	1.2
Porters black loam	448	64	512	.1
Total	315,328	316,800	632,128	100.0

CECIL CLAY.

The Cecil clay is a red clay loam of sticky, tenacious character, and is usually a heavy soil to work. The depth of the soil varies from 6 to 9 inches. The subsoil is a purer red clay of more sticky and tenacious character than the soil. The depth of the subsoil is usually several feet. Throughout both soil and subsoil there are often numerous fragments of quartz, and sometimes fragments and bowlders of basalt.

Sometimes this type is a very heavy, tenacious red clay from the top down, and sometimes the underlying rock is found only a few feet below the surface.

The Cecil clay, which is confined to the Piedmont Plateau, is chiefly found in one continuous belt extending in a northeast-southwest direction from the vicinity of Reepsville, past Newton, across the Catawba River near the great bend, to Scotts Cross Roads, and on into Iredell County. Usually where large areas of this soil occur there is a great uniformity in surface features. Throughout the Piedmont Plateau there are small, isolated patches of Cecil clay, but often, owing to the

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location, these red-clay patches have been formed by the sand washing off of what would naturally be Cecil sandy loam and exposing the subsoil of the latter. When properly cared for such patches can be made as productive as the typical Cecil clay.

This type of soil has been formed from the slow weathering of granite, gneiss, and schist, and is a residual soil. The quartz scattered on the surface is derived from dikes that have not weathered as readily as the surrounding rocks.

This soil is recognized as one of the most fertile in the area, and where it is found the general appearance of the farms is better than on the other types. The soil is readily improved, retains added fertility well, and is generally recognized as being capable of a high state of cultivation. It is well adapted to nearly all general farm crops, but is especially well adapted to wheat, which returns yields as high as 40 bushels to the acre. The average yield, however, is less than 20 bushels. Next in importance to wheat are cotton and corn. With the best of treatment the soil will produce 1 bale of cotton to the acre, but the average is about one-half bale. The average yield per acre of corn is about 30 bushels. Cowpeas are grown extensively, both for forage and as green fertilizer. Very little clover is grown, but from the appearance of the few fields seen it is evident that this soil is very well adapted to this crop.

The following table gives mechanical analyses of soil and subsoil of the Cecil clay:

Mechanical analyses of Cecil clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7318	1 mile S. of Sloan...	Red clay loam, 0 to 7 inches.	1.68	4.16	9.68	8.34	20.64	10.96	22.66	22.96
7320	2 miles N. of Conover.	Red clay loam or clay, 0 to 6 inches.	1.36	4.56	9.48	6.18	14.92	8.10	25.74	30.26
7322	Louise..............	Clay loam, 0 to 7 inches.	2.15	8.90	13.40	7.32	15.08	9.04	23.76	21.84
7323	Subsoil of 7322......	Sticky red clay, 7 to 36 inches.	.50	5.00	9.30	4.88	11.22	6.28	20.68	42.02
7319	Subsoil of 7318......	Stiff red clay, 7 to 36 inches.	.69	2.90	7.42	9.14	18.70	8.62	26.96	26.08
7321	Subsoil of 7320......	Sticky red clay, 6 to 36 inches.	.19	2.40	5.12	3.64	8.70	5.72	23.32	50.04

CECIL SANDY LOAM.

The Cecil sandy loam is a gray or grayish-yellow sandy loam, varying in depth from 8 to 15 inches, underlain by a subsoil of red clay,

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usually of a stiff, tenacious character and having a depth of several feet. Throughout both soil and subsoil there are often numerous fragments of quartz. This type is one of the most widely distributed of any in the Piedmont section of the area.

While in general the Cecil sandy loam has a red clay subsoil, occasionally the subsoil is reddish-yellow or yellow. Throughout the area there are on the hillsides places where sand has been washed away, leaving the subsoil exposed. These places, locally called "gall spots," have the general appearance of Cecil clay. Such spots, where larger than 10 acres, have been included with that type. Smaller areas have been classed with the Cecil sandy loam.

The surface features of the Cecil sandy loam areas include all of the general features of the Piedmont Plateau, varying from broad, uniform uplands to areas dissected by numerous streams. The soil is always well drained.

Like the Cecil clay, this soil is a residual soil formed by the slow weathering of granite, gneiss, and schist; but there is this difference, the rocks from which the Cecil sandy loam is derived have a greater proportion of quartz in their composition, and hence the greater abundance of sand in the soil.

The principal crops grown are cotton, corn, wheat, oats, cowpeas, and sweet potatoes and other vegetables. Cotton is the principal crop, and the average yield per acre is one-half bale, although the best farmers often secure as much as 1 bale to the acre. When the ground is well cared for and fertilized the average yield per acre of corn is 25 to 35 bushels, and that of wheat, under the same conditions, about 12 bushels. The possibilities of this soil for sweet potatoes are shown in the vicinity of Hickory, where several farmers are specializing that crop. In 1901 110 carloads were shipped from that place to Northern and Eastern markets. The average yield is about 200 bushels per acre. Mr. J. Ingold raised as high as 345 bushels per acre last year. This soil is fairly well adapted to all general farm crops, and when not too near the mountains seems especially well adapted to cotton, sweet potatoes, and vegetables. The soil requires careful treatment to bring out its possibilities.

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The following table contains mechanical analyses of the soil and subsoil of the Cecil sandy loam:

Mechanical analyses of Cecil sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7324	6 miles N. of Conover.	Grayish-yellow sandy loam, 0 to 15 inches.	0.76	7.00	11.42	9.16	27.02	17.66	18.48	8.72
7326	2¼ miles E. of Hickory.	Gray sandy loam, 0 to 10 inches.	1.68	8.16	17.48	9.76	19.94	11.16	22.26	10.90
7328	Taylorsville	Grayish-yellow sandy loam, 0 to 10 inches.	.82	10.06	17.12	11.88	23.04	9.86	15.16	12.56
7327	Subsoil of 7326.......	Yellowish-red clay loam, 10 to 36 inches.	.68	7.44	14.38	8.30	15.26	7.54	16.40	30.68
7329	Subsoil of 7328.......	Red clay loam, 10 to 36 inches.	.80	4.74	6.26	5.30	16.84	10.36	17.04	39.96
7325	Subsoil of 7324.......	Red clay loam or clay, 15 to 36 inches.	.41	2.74	6.60	5.00	17.18	10.66	13.82	43.64

DURHAM SANDY LOAM.

The surface soil of the Durham sandy loam is of a light-gray color and has a depth varying from 8 to 20 inches. The subsoil is a yellow clay loam, usually several feet in depth. Quartz fragments of various sizes are often strewn upon the surface. This is a Piedmont Plateau soil, and in the Hickory area was found only in the vicinity of Rocky Springs, Edith, and Reepsville. It seems to be confined to the broad, level uplands, but is well drained, owing to the porosity of both soil and subsoil. It is a residual soil derived from the weathering of gneiss, schist, and a variety of pegmatite granite.

Of the soils in the Piedmont Plateau this is one of the poorest. Nearly all of the general farm crops, such as cotton, corn, oats, and sweet potatoes, are grown on it, but the yields are not high, even where the methods are best. The average yield per acre of cotton is hardly one-half bale, that of corn about 15 bushels, and of oats about 15 bushels. The soil seems well adapted to sweet potatoes, the average yield being 200 bushels per acre. It is equally well adapted to tobacco, but none is now grown, owing to competition with more eastern sections of the State. It is well adapted to truck farming. It is not usually used for wheat, but when it is the yield is about 8 bushels per acre. Apples and peaches seem to do fairly well. The original fertility and added manures leach from this soil very rapidly, and it needs

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the constant addition of plant foods and careful handling to prevent its rapid deterioration. This type is known locally as "piny woods land."

The following table gives mechanical analyses of the Durham sandy loam:

Mechanical analyses of Durham sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7332	2 miles E. of Carson.	Grayish-yellow sandy loam, 0 to 8 inches.	1.76	15.42	25.54	13.72	19.58	8.54	11.00	5.70
7334	Rocky Springs......	Sandy loam, 0 to 12 inches.	.94	12.54	24.68	12.38	19.00	8.06	16.62	6.46
7330	1¼ miles NW. of Bandy.	Yellowish-gray sandy loam, 0 to 8 inches.	1.47	11.52	15.46	11.14	20.20	11.04	21.92	8.14
7335	Subsoil of 7334......	Yellow clay loam, 12 to 36 inches.	.26	11.24	19.92	9.68	14.84	6.16	17.30	20.64
7333	Subsoil of 7332......	Yellow loam, 8 to 30 inches.	.35	11.88	17.52	10.22	14.88	6.40	8.46	30.48
7331	Subsoil of 7330......	Yellow loam, 8 to 36 inches.	.92	4.44	6.02	4.60	9.42	5.36	17.78	52.24

PORTERS SANDY LOAM.

The Porters sandy loam consists of a grayish-yellow or red sandy loam or loam with an average depth of 7 inches underlain by a subsoil of sticky, tenacious red clay often with a depth of several feet. In both soil and subsoil, and often on the surface, are fragments of quartz and other rocks.

This soil bears the same relation to Porters clay as the Cecil sandy loam does to the Cecil clay, and is distinguished from Porters sand by the fact that it has a stiff, tenacious red clay subsoil.

It is found on the mountain tops, mountain slopes, in the valleys between the mountains, and on the high, rolling lands between the mountains and the Piedmont Plateau.

This soil is a residual soil formed from the slow weathering of the same kinds of rocks as Cecil sandy loam.

In the mountain valleys and on high, rolling lands it is regarded as a good soil for general farm purposes. The seasons here are too short for the profitable growing of cotton. Wheat, corn, oats, rye, sweet and Irish potatoes, and fruits are the principal crops.

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The following table contains mechanical analyses of the soil and subsoil of the Porters sandy loam:

Mechanical analyses of Porters sandy loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7340	Hibriten	Grayish sandy loam, 0 to 9 inches.	2.29	5.20	17.50	14.78	27.74	10.26	14.44	9.86
7342	3 miles N. of Partee.	Sandy loam, 0 to 8 inches.	1.02	5.86	8.94	8.08	32.42	15.04	15.24	14.42
7356	Barretts Mountain	Sandy loam, 0 to 8 inches.	1.58	6.92	12.98	9.20	21.90	14.04	19.48	15.40
7357	Subsoil of 7356	Stiff red clay, 8 to 36 inches.	.47	2.76	6.74	5.24	16.94	9.00	21.50	37.86
7341	Subsoil of 7340	Stiff red clay, 9 to 36 inches.	.48	4.06	11.38	7.94	14.56	5.80	13.94	42.32
7343	Subsoil of 7342	Stiff red clay, 8 to 36 inches.	.35	3.30	6.32	5.50	18.08	7.10	14.96	44.28

PORTERS CLAY.

The Porters clay is in its general characteristics and process of formation essentially the same as the Cecil clay. It is a tenacious red clay with an average depth of 6 inches, underlain by a stiff, tenacious red clay to a depth of 36 inches or more.

Occasionally it was found that where this type grades into the Porters sandy loam it becomes loamy itself; and sometimes it was found that the subsoil ran into disintegrated rock only a few feet below the surface. There is usually a considerable quantity of quartz and other rocks strewn upon the surface, and sometimes the proportion of rock in both soil and subsoil is very great.

Whatever difference there is between this soil and the Cecil clay in adaptation to crops and in crop yields is due largely to its position. The type is confined to the mountain areas, but there it is found in all locations, from the intervening valleys to the mountain tops. A good example of its occurrence in mountain valleys is found to the east and northeast of Lenoir. In those valleys, it is said, the soil is not quite as good as the red clay of the Piedmont area, because it becomes "as hard as a brick" in dry times. But with deeper plowing the condition can be greatly alleviated.

The Porters clay is a residual soil formed, as is Cecil clay, from the slow weathering of granite, gneiss, and schist. Owing to its position in the mountains it is a well-drained soil. It is adapted to all of the

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general farm crops of the area except cotton, and it is not adapted to the latter because the growing season is too short for proper maturity of the bolls. The average yield of wheat per acre is about 15 bushels and that of corn about 18 bushels. Oats do very well, but are not usually thrashed, being fed to stock in the sheaf. With fertilizer and proper preparation of the ground wheat sometimes yields as high as 25 bushels per acre, and corn, with the same care and attention, does proportionately as well. Excepting the bottom lands, it is recognized as the strongest land of the mountain area. It is best adapted to wheat and apples, and is a good pasture land.

The following table gives mechanical analyses of the soil and subsoil of Porters clay:

Mechanical analyses of Porters clay.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7362	Vashti..............	Red clay loam, 0 to 6 inches.	2.24	4.14	12.30	9.16	19.44	10.02	18.52	25.72
7360	Kings Creek........	Clay or clay loam, 0 to 7 inches.	.91	3.54	9.30	8.40	24.38	14.86	12.40	26.12
7358	1 mile SW. of Hibriten.	Brownish-red clay loam, 0 to 6 inches.	1.11	3.00	13.50	9.84	21.00	10.14	13.94	28.32
7363	Subsoil of 7362......	Stiff red clay, 6 to 36 inches.	.47	5.10	11.94	8.54	16.10	7.80	11.28	39.20
7361	Subsoil of 7360......	Stiff red clay, 7 to 36 inches.	.28	1.74	5.44	4.50	13.20	12.20	18.40	45.46
7359	Subsoil of 7358......	Stiff red clay, 6 to 36 inches.	.36	2.94	7.88	4.64	9.32	6.76	19.22	49.00

CONOWINGO CLAY.

The surface soil of the Conowingo clay is a grayish-yellow gravelly loam about 8 inches in depth. The surface is strewn with small pieces of magnetite iron and fragments of talc schist, the latter sometimes in large quantities. The subsoil is a reddish clay loam, running into solid rock at from 2 to 5 feet below the surface. The underlying rock is talc schist and is locally known as "red soapstone." This rock is scattered throughout both soil and subsoil. This type is found in the Little Brushy Mountains, and extends in an irregular belt, often 4 or 5 miles wide, from the vicinity of Valdese northeast to Taylorsville. Owing to its position this type is well drained, but unless very well cared for it is a poor soil. Owing to the erosive power of the gravel when carried along by the surface water the soil washes badly.

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The areas where this type is found were until recently covered with forests, but the large timber has been cut off.

The Conowingo clay is a residual soil, derived from the weathering of talc schist.

All of the general farm crops of the country are grown upon this soil. Its position near the mountains, however, makes the season too short for profitable cotton growing. Corn yields from 12 to 15 bushels per acre, wheat from 5 to 15, and oats average about 15 bushels per acre. Deep plowing greatly improves the land. Fragments of the talc schist brought to the surface seem upon weathering to have some value as a fertilizer. When deep plowing is practiced this soil seems fairly well adapted to wheat, yields as high as 18 bushels per acre sometimes being secured. The possibilities of this soil for grapes is demonstrated by what has been done by the colonists at Valdese, near Morganton.

The following table gives mechanical analyses of the soil type:

Mechanical analyses of Conowingo clay.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7344	1¼ miles S. of Cedar Valley.	Grayish-yellow gravelly loam, 0 to 8 inches.	1.88	7.60	14.14	8.84	19.88	13.74	24.18	11.48
7348	Taylorsville	Grayish-brown gravelly loam, 0 to 8 inches.	1.09	15.50	17.16	9.80	16.98	9.22	17.84	12.90
7346	1 mile NE. of Hudson.	Grayish-yellow gravelly loam, 0 to 6 inches.	2.86	6.42	16.80	10.34	22.52	12.54	16.38	14.88
7349	Subsoil of 7348	Reddish-yellow loam, or gravelly loam, 8 to 36 inches.	.72	14.34	16.46	7.82	12.36	5.84	11.34	31.52
7347	Subsoil of 7346	Reddish-yellow gravelly loam, 6 to 24 inches.	1.70	8.98	16.94	9.50	14.92	7.02	8.44	34.42

PORTERS BLACK LOAM.

The Porters black loam is a loose, black loam varying in depth from 6 to 20 inches and having a red clay subsoil, often several feet deep. Throughout the soil there is a large proportion of organic matter, and throughout both soil and subsoil, and also on the surface, are found many rock fragments of all sizes.

Where conditions are favorable this soil often attains a depth of 2

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feet, but usually it is much shallower. Often the subsoil runs into disintegrated rock a few feet below the surface, and sometimes the subsoil, instead of being a clay, is a coarse sandy loam. This type is confined to the mountainous part of the area, and is found either on the tops of the mountains or in the coves on the mountain slopes. From its position it is naturally well drained.

The chief characteristics of this type are its loose texture and black color. It is apt to occur anywhere where the decomposition of organic matter is slower than the accumulation. The organic matter is usually intimately mixed with the soil, the mineral particles having been supplied partly by weathering of the underlying rock and partly by wash from the surrounding steep mountain slopes.

All crops which are grown in the mountains do well upon this soil, but it will not stand extensive cultivation on account of its tendency to wash when stirred up. It is becoming generally recognized as the very best soil of the country for apples. With proper attention apples do well on almost any of the mountain soils, but upon the Porters black loam they seem to thrive without any particular attention. Both the early and late varieties of apples are grown to perfection. Among the early varieties the most popular are Greensboro Striped June, Greensboro Red June, and Yellow Transparent. Of later varieties the Red Limbertwig and Johnsons Seedling are most in favor.

The following table gives the mechanical analyses of soil and subsoil of Porters black loam:

Mechanical analyses of Porters black loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7350	1½ miles W. of Draco.	Loam, 0 to 12 inches.	4.19	4.00	9.04	8.38	26.20	18.32	20.10	13.50
7354	Lick Mountain	Loose black loam, 0 to 15 inches.	4.27	8.50	13.44	9.50	25.84	10.50	17.74	13.82
7352	½ mile SE. of Hibriten.	Loose black loam, 0 to 18 inches.	4.23	7.68	14.28	10.70	23.98	11.48	15.62	16.26
7355	Subsoil of 7354	Yellowish sandy loam, 15 to 36 inches.	.99	7.74	13.20	10.08	27.16	11.30	17.20	13.02
7353	Subsoil of 7352	Yellowish sandy loam, 18 to 36 inches.	.57	7.24	13.86	9.90	26.76	11.00	17.76	13.44
7351	Subsoil of 7350	Red clay loam, 12 to 36 inches.	1.84	3.74	9.10	7.94	20.98	12.28	15.92	30.26

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PORTERS SAND.

The Porters sand is a grayish-yellow coarse sand, with an average depth of about 12 inches, underlain by a subsoil of coarse yellow sand or sandy loam, running into rock in various stages of disintegration a few feet below the surface. Considerable quantities of rock fragments are strewn upon the surface and mingled throughout both soil and subsoil.

This soil is confined to the mountainous area, and may be found at all elevations, from the top of the mountains down to the steep slopes of the lower ridges extending out into the plateau from their base. Larger areas of this soil occur on the south side of the Brushy Mountains than on the north side.

The parts of the area where this soil is found are usually thinly settled, and large areas of it are still covered with good timber. When cleared and cultivated this soil washes so badly that it is regarded as a poor soil for farming purposes. Where the elevation is right and the inclination not too steep peaches do well.

The following table gives mechanical analyses of soil and subsoil of Porters sand:

Mechanical analyses of Porters sand.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7366	2 miles N. of Emanuel.	Grayish-yellow sandy loam, 0 to 12 inches.	0.77	12.50	17.04	11.30	24.44	16.66	12.78	4.88
7368	1 mile SW. of Vashti.	Yellowish sandy loam, 0 to 10 inches.	.85	9.84	19.84	11.64	26.94	12.34	12.36	7.20
7364	1 mile N. of Draco..	Grayish-yellow sandy loam, 0 to 12 inches.	1.82	13.52	22.80	12.18	17.76	8.02	11.62	13.82
7367	Subsoil of 7366......	Yellowish loam or sandy loam, 12 to 36 inches.	.16	10.52	17.58	11.84	25.74	16.76	13.50	4.10
7369	Subsoil of 7368......	Coarse yellowish sandy loam, 10 to 36 inches.	.27	12.74	22.20	13.24	24.80	10.36	7.56	8.92
7365	Subsoil of 7364......	Coarse yellow sandy loam, 12 to 36 inches.	.23	15.70	19.70	11.44	18.92	7.82	13.84	12.02

MEADOW.

In the present area the Meadow includes all low-lying bottom lands subject to flooding. It is a soil formed by the deposit left from the

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overflow of streams. Its materials are heterogeneous and of varied origin. Sometimes they may be derived from the local wash from near-by hills, and again they may have come from the mountains hundreds of miles away. A description which would apply to some particular locality might not apply to any other locality. Some of these bottom lands were among the first to be cleared and cultivated when the country was settled, and to-day some of them are among the most valuable lands of the area. In their original condition they were covered with cane, alder, and larger trees, and were quite swampy. When they were cleared and drained this swampy condition disappeared. Since the introduction of cotton into the area a great deal of the loose soil from the hills has been carried down into the streams. This, together with the cutting off of so much timber, both within the area and in the mountains to the north and west, has made freshets more frequent and as a result the bottoms have been filling up. In many cases the channels have been so filled as to make gravity drainage impossible because of the lack of fall. Some of the meadow land has become swampy, and more has been covered over with a coating of barren white sand. Where the meadow has not been thus ruined it is still the best land of the area for corn and grass.

PORTERS STONY LOAM.

The Porters stony loam is a grayish-yellow sandy loam, with an average depth of about 8 inches, beneath which occurs a subsoil of yellowish or sometimes reddish loam. Mingled with both soil and subsoil and scattered on the surface are great quantities of rock fragments.

This soil is a mountain type, and in reality represents a condition rather than a group of definite textural characteristics. Under this term was included all land too rocky and steep to cultivate. Occasionally, however, there were small areas in the midst of larger areas of this soil that could be used for agricultural purposes. The rocks on such areas are occasionally collected and built into fences or thrown into ravines. The mountainous position of this type makes it desirable for apples, peaches, and grapes wherever it is sufficiently free from rocks or where it is practicable to remove them by hand. One of the successful apple growers in the Little Brushy Mountains has gathered the stones and either made fences of them or built stone walls across mountain ravines at equal intervals, placing above each wall an apple tree. (See Pl. VIII.) The accumulation of fine material and the retention of moisture about the roots of the tree, resulting from this method, are said to be very favorable to its growth. On Barrett Mountain some of the best peach orchards of the area are growing upon Porters stony loam. The success of these orchards depends, probably, as much upon location as upon the nature of the soil, as the areas in orchard lie above what is known as "the frost line." These areas are used exclu-

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sively for fruits, being too steep and stony for cultivated crops or grains. Many of the areas have very valuable hard-wood timber growing upon them.

The following table contains mechanical analyses of soil and subsoil of the Porters stony loam:

Mechanical analyses of Porters stony loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7336	Barretts Mountain	Grayish-yellow stony loam, 0 to 7 inches.	3.10	7.10	14.56	9.90	21.12	9.32	28.24	9.28
7338	Downsville	Grayish-yellow sandy loam, 0 to 10 inches.	1.57	3.16	10.34	9.12	35.94	11.26	19.04	10.80
7339	Subsoil of 7338	Yellowish loam, 10 to 36 inches.	.84	3.02	8.30	7.00	31.74	16.48	20.38	12.94
7337	Subsoil of 7336	Yellow loam or clay loam, 7 to 30 inches.	1.46	4.12	11.42	9.30	18.88	8.50	24.78	22.52

SOIL PROBLEMS.

There are two chief soil problems before the farmers of the Hickory area. One is particularly limited to the area north of Catawba River, and is the restoration of the fertility and productiveness of many farms in that part of the area. The present plight of these farms is due to the careless and inefficient methods of cultivation, among which may be enumerated the absence of a proper system of rotation of crops, the constant cropping to cotton, corn, or wheat, shallow plowing, improper or imperfect cultivation, inviting gullying, and the leaving of the fields unprotected by vegetation during the winter season, thus accentuating the loss of fertility by leaching and washing.

Much of the area in these farms can be rejuvenated by a reversal of these methods, by adding to the crop rotation one or more of the legumes, and by increasing the number of live stock carried on the farms and husbanding the manure made by these animals in consuming the forage afforded by the legumes, the corn fodder, and the native grasses.

Deeper plowing, gradually letting the share cut deeper year by year, and thus bringing only a little of the subsoil to the surface in any one year, will be found of great value both in renewing the fertility of the worn-out fields and in decreasing the tendency of the soils to wash. The increasing of the porosity of the soil by incorporating

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with it the stubble of clover and cowpeas and coarse stable manure also helps to prevent washing, while at the same time adding needed organic matter.

The other problem is the reclamation of the bottom lands, many of which have become in recent years too wet for cultivation, or, even where cultivable, subject to more frequent overflow than formerly. This change has resulted from the silting up of the channels. Some of the bottom land along the Catawba River, the most valuable soil of the area for the production of corn and grass, is to-day almost valueless because of a thick deposit of barren white sand brought down by the flood of the spring of 1901.

The chief factors in the deterioration of the bottoms are the rapid deforestation of immense areas of mountain woodlands and the constant shallow cultivation of the fields in cotton and corn. The removal of surface soil by the heavy rains is, as a result, greatly increased, and the filling up of the stream channels and flooding of the meadow areas follows. The proper tilling of the fields will tend to decrease the amount of silt carried by the streams. The springing up of young forests on the denuded mountains will tend to lessen the frequency of floods, and in time the streams may again deepen their channels so that drainage of the bottom lands will be reestablished and their cultivation reentered upon. Those areas covered with deposits of pure sand are probably permanently ruined as far as agriculture is concerned, unless subsequent floods shall add other material or remove the sand deposits.

AGRICULTURAL CONDITIONS.

The whole area has been an agricultural one since the time of its first settlement. The section about Newton, Hickory, and Lincolnton is very prosperous. The lands have the highest average value of any in the State. This prosperity is due primarily to the abundance of Cecil clay and a good type of Cecil sandy loam, and the favorable climatic conditions, together with the sturdy, industrious class of people who own these lands.

In recent years the railroads have opened up ready markets for farm products. Until very recently these communities were purely agricultural ones, but the abundance of excellent cotton and timber lands and good water power, together with the tendency of industries to move southward, is gradually transforming this section into an industrial community, so that some of the old towns have doubled their population, and new towns have grown up around the cotton mills and furniture and wagon factories. This additional growth has created additional demands for farm produce, so that farming is receiving new stimulus. Formerly considerable tobacco was grown in the area, but when most of the tobacco factories of the State went into

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the hands of one company the growers in less favored localities had to abandon this crop, because of a lack of competition in the tobacco market.

The owners of the soil are nearly all descendants of the sturdy German and Scotch-Irish stock who first settled that section of the country, and in many cases the farms have remained in the hands of the same family from the time of settlement. The farms are small, the average size being about 125 acres. The owners do their own work and do not depend upon the inefficient labor of the locality. The lands are free from mortgage and there is an abundance of improved machinery. The houses are substantial, and the barns and sheds, though not pretentious, are sufficiently large to house the crops of such a climate. There is a diversity of crops, so that a failure of one does not mean a failure for the year. There are no very wealthy farmers and no very poor ones, so that all are about on an equality. Not much of the land is for sale, but there are plenty of opportunities for poor men to start a home. The lands can be cleared and planted without the expense of fencing, as the stock law protects the crops. For such a prosperous section the wagon roads are very bad, but the property owners are beginning to realize that good roads enhance the value of their property. Wagon roads are usually built along some of the many ridges traversing the area. The railroads generally follow the same plan. Along the main traveled highway from Taylorsville to Statesville, a distance of 20 miles, the wagon road crosses the railroad twenty-seven times. The same condition exists between Newton and Morganton. Where the railroad traffic is great accidents are common. Such a condition ought not to exist; highways should be kept a safe distance from the railways.

The soils are principally residual soils derived from gneiss and schist by the slow process of weathering. Aside from the heterogeneous bottom lands the important soils are the Cecil clay and Cecil sandy loam. The Cecil clay is recognized as the strongest soil of the section because it is capable of the highest state of improvement. It is a difficult soil to work, but maintains fertility well. It is well adapted to all general farm crops of the section, but is especially adapted to wheat. The Cecil sandy loam is also capable of a high state of cultivation, but improvements in fertility and condition are not as permanent as in the case of the Cecil clay, nor is the soil as well adapted to wheat as the Cecil clay. It is better adapted to sweet and Irish potatoes and to vegetables. In the vicinity of Hickory sweet potato culture has become a very important industry on this soil. Less than a score of years ago this crop was not grown in the area for market. When it was found how successfully it could be grown, Asheville and other near-by markets were supplied, but the supply soon became greater than the demand. The board of trade at

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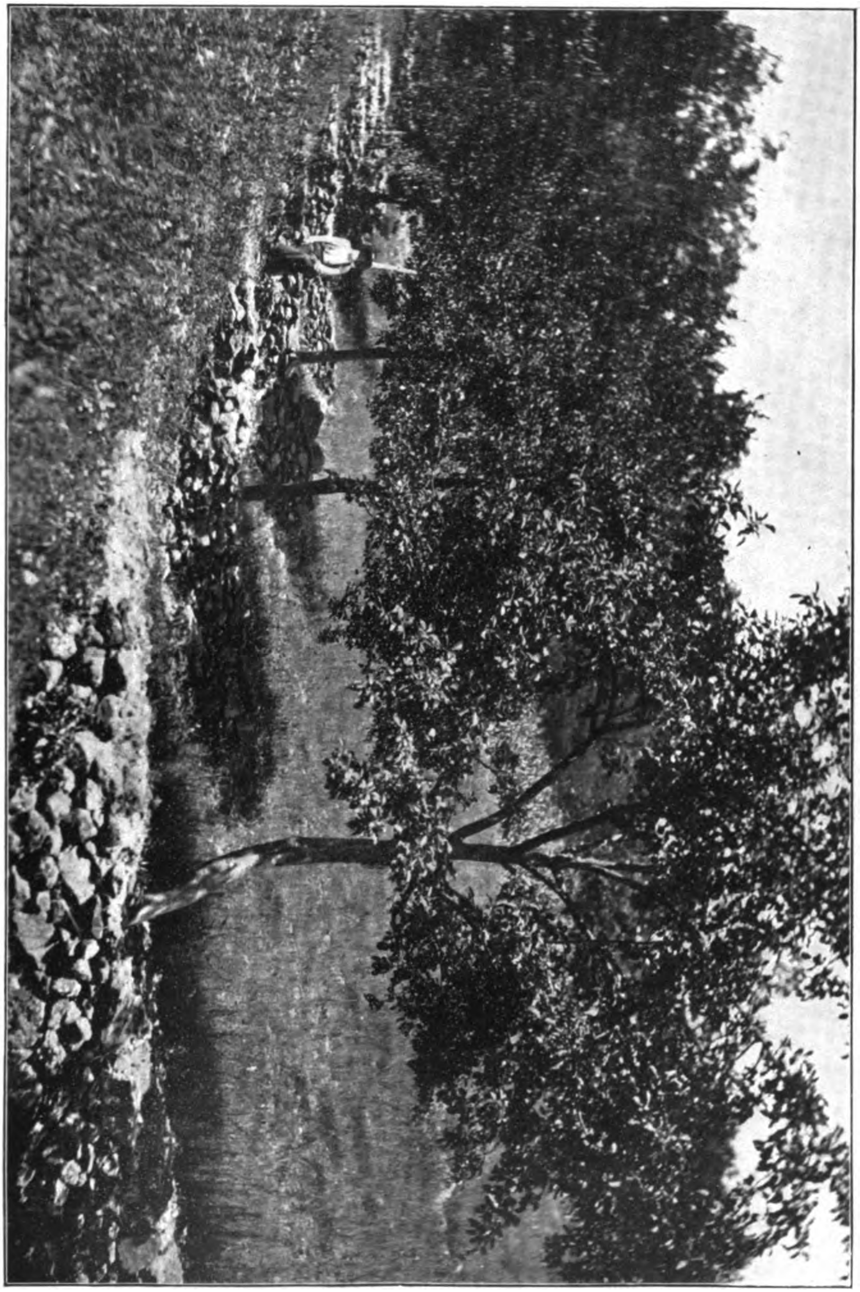

APPLE TREES ON PORTERS STONY LOAM, CEDAR VALLEY, HICKORY AREA, NORTH CAROLINA.

Showing piles of stones on the lower side of the slopes to hold the soil in place.

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Hickory then took the matter up and obtained concessions in freight rates to Northern markets. New York, Boston, Pittsburg, and Cincinnati are among the present markets. Over a hundred carloads were shipped from the vicinity of Hickory in the fall of 1901.

The small areas of Durham sandy loam in the vicinity of Hickory and Newton were formerly used for tobacco. These areas, also, are now successfully cultivated in sweet and Irish potatoes and vegetables, besides being suited to the production of the general farm crops common to the area. The bottom lands have always been used for corn and grass, and where they are not too wet they are still used for those crops.

The Conowingo clay, along the border of the Piedmont Plateau at the foot of the mountains, is generally regarded as a poor soil. When plowed deep, this soil does moderately well for all general farm crops except cotton. Its nearness to the mountains makes the climate too cool for cotton. The possibilities of this soil for grape culture are demonstrated by the large and beautiful vineyards of the colony from northern Italy who founded the town of Valdese, just outside of the area. The Porters sand and Porters stony loam, on the tops of the mountains above what is known as the "frost line," are especially well adapted to peaches. This is attested by the successful peach orchards on Barrett Mountain. With proper attention apples do well upon almost any of the mountain soils. At Cedar Valley Mr. H. P. Anderson is making a great success of the production of apples upon the Porters stony loam—a poor, rocky soil. As mentioned in the description of that soil type, he builds stone walls across the mountain ravines and above each wall sets out a tree. The soil gradually accumulates around the bottom of the tree and the depression has a tendency to retain the soil moisture, making the conditions favorable to rapid and vigorous growth. The greatest success with apples in the mountains, however, seems to be upon the loose, black, loamy soil (Porters black loam) which sometimes accumulates on the mountain tops, but more often in the sheltered coves. This soil is usually rich in organic matter, which is intimately mixed with fine soil washed from higher ground and with rock fragments of all sizes. Its loose texture and cool, sheltered location make it especially adapted to late varieties of apples. The bottom lands in the mountain valleys are also well suited to the production of apples. The possibilities of apple growing on a commercial scale in the Brushy Mountains are demonstrated in the vicinity of Kilby, a few miles north of Taylorsville, and also on Lick Mountain, a few miles north of Hudson. The former orchards are growing in Porters sandy loam and the latter in Porters black loam.

The commercial orchards in Wilkes and Alexander counties are being damaged by two very injurious fruit diseases. An expert

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examination of the diseased parts of several trees show that the diseases are an apple rust due to a fungus known as *Glœosporium versicolor*, and the fire blight. These diseases are becoming very destructive and deserve immediate attention, but in a report of this kind it would be impossible to give full details for preventing and curing them. They have been fully considered in other reports which can be obtained by request. The reports on the apple rust are Bulletin No. 44 of the Kentucky experiment station, and Farmers' Bulletin No. 38 of the North Carolina department of agriculture. Fire blight is treated in Bulletin No. 40 of the Colorado experiment station and Farmers' Bulletin No. 153 of the North Carolina department of agriculture. All of these deserve careful study.

Not much attention is given to the fruit industry in the Piedmont section of the area, although enough apples, peaches, pears, and grapes are usually grown to meet the local demand. The Cecil sandy loam is very well adapted to nurseries, and at Startown there are hundreds of acres devoted to this industry. It is only in the mountainous portion of the area, where the climatic conditions are more favorable, that the fruit industry is upon a commercial basis. It has been observed that the successful production of fruit in the area is gradually moving northward, and that many varieties of apples which formerly did well along the border of the Piedmont Plateau can now be grown successfully only in the mountains several miles farther north. This change is thought to be due to the cutting of so much timber and the resulting change in climatic conditions.

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SOIL SURVEY OF THE MOUNT MITCHELL AREA, NORTH CAROLINA.

By THOMAS A. CAINE and A. W. MANGUM.

LOCATION AND BOUNDARIES OF THE AREA.

The region surveyed is a rectangle lying between 82° and 82° 30′ west longitude, and 35° 45′ and 36° north latitude, and includes most of Yancy and Mitchell counties and parts of Madison, Buncombe, and McDowell counties. The area contains about 500 square miles and is located in the highest part of the United States east of the Rocky Mountains. (See fig. 5.)

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

After the close of the French and Indian wars and after the expulsion of the French and Spanish from the South, the Scotch and Scotch-Irish began to immigrate to North Carolina and South Carolina in great numbers. In North Carolina a few settled in the eastern part of the State, but most of them went to the higher mountain lands to the westward, probably because the climate was more congenial to them.

These people were naturally hardy and brave, and soon wrested the lands from the Indians and carved prosperous settlements out of the wilderness. They kept pushing westward to the higher country over the Blue Ridge. In the area surveyed the inhabitants nearly all trace their ancestry to these early Scotch-Irish settlers.

The great tides of immigration passing into the United States during the last century seem to have moved along lines of latitude westward, and the South has been remarkably free from the infusion of foreign elements. The reason is probably due somewhat to climatic conditions and also to the better facilities of travel through the waterways of New York and along the Great Lakes to the West. Here in this mountain country is probably to be found the purest strain of American blood in the United States.

The country is very rugged, and transportation and travel very difficult. The lines of travel were through the valleys, along the lines of least resistance. In these valleys the soils are more fertile and easily worked, and hence they were the first to be taken up. In time the valleys became cleared throughout their length, and often the lower slopes of the adjoining mountains were put under cultivation.

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Where the valleys were wide and fertile enough to support several families a settlement grew up, which afterwards became either the center of a township or of a county.

For generations the settler bought little and sold little, because of the distance from market. A little dependence was placed on hunting and fishing, but the chief source of revenue was cattle and hogs. No fences were required, except to protect the garden and corn patch. The stock was branded and turned loose in the mountains, the cattle living upon the grass and the hogs feeding upon the abundant mast. As a class the people never have been wealthy, but are all about on an equality. For generations they have been content with making a good living, without accumulating for their children or keeping pace with agriculture in other sections of the State.

The conditions for slavery were never favorable in this section, and the community was affected very little by the civil war.

This region has been contributing for generations a sturdy class of emigrants, who have gone out and helped to build up the Southwest, as they are now going into the Northwest. If this mountain region of such great possibilities has been behind in development, it is because of lack of railroad facilities and the difficulty of travel. Its possibilities and the capability and industry of the people are shown in the vicinity of Asheville, and the changes there have all been wrought since that town became a railroad center.

In the parts of the area farthest removed from the railroads, however, the people have not changed greatly. The log cabin is still about the only dwelling, and the mountaineer is still content with barely making a living, apparently not caring for the rapid advance his competitors in other parts of the State are making.

CLIMATE.

The difference in the altitude of that part of the area lying in the plateau south of the Blue Ridge Mountains and that which lies north and west of the Blue Ridge causes a great difference in the climatic conditions of the two principal physiographic divisions of the area surveyed. There are no Weather Bureau stations within the area, but the records of the station at Linville, a few miles northeast of the area, show the climatic conditions of the mountainous section, while those of Marion, situated just south of the area, show the conditions as they exist in the lower plain, south of the mountains. The climate of the mountainous section is much the cooler, and the season for growing crops is shorter, frosts coming much earlier in the fall and occurring later in the spring. Although the winters are colder than those of the Piedmont Plateau, they are comparatively mild. The mild winters, cool summers, and the pure, dry mountain atmosphere

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cause the climate of the whole area to be considered one of the most healthful in the Southern States.

The following tables give the temperature and precipitation, and the occurrence of killing frost at the stations already mentioned:

Temperature and precipitation.

Month.	Linville.		Marion.	
	Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	Inches.	°F.	Inches.
January	31.0	3.08	37.6	3.84
February	31.0	4.08	42.0	4.24
March	40.5	....	49.1	3.39
April	42.2	....	57.6	3.07
May	55.7	....	66.0	5.22
June	62.4	....	72.3	4.91
July	66.1	....	80.7	5.91
August	64.9	....	78.3	4.01
September	58.7	4.59	....	....
October	47.3	1.86	58.1	4.44
November	41.4	5.58	48.7	3.66
December	34.8	5.60	40.4	2.68
Year	48.6	....	....	....

Dates of killing frosts.

Year.	Linville.		Marion.	
	Last in spring.	First in fall.	Last in spring.	First in fall.
1896	Apr. 11	Sept. 24	Apr. 9	Oct. 19
1897	May 27	Sept. 21	Apr. 21	Nov. 18
1898	May 10	Oct. 16	Apr. 28	Oct. 23
1899	Apr. 17	Sept. 22	Apr. 17	Oct. 1
1900	May 11	Nov. 5	Apr. 5	Nov. 9
1901	Apr. 24	Sept. 20	Mar. 29	Nov. 6

PHYSIOGRAPHY AND GEOLOGY.

The great Appalachian Mountain system, which extends in a northeastern-southwestern direction from Maine to Alabama, reaches its highest elevation in western North Carolina. This region of highest elevation may be considered as a plateau, with an average altitude of about 3,000 feet, of which the Blue Ridge forms the eastern boundary and the Smoky Mountains the western boundary. Resting upon this plateau are numerous cross chains, extending at right angles to the general trend of the system and rising in some instances to over 3,000 feet above the plateau itself. (See Pl. IX.)

It was in the midst of this high mountainous region that the survey was carried on, and the area included one of the most massive and

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conspicuous of these cross chains, namely, the Black Mountains, in which is Mount Mitchell, the highest point in the United States east of the Rocky Mountains. The lowest point in the area is on the north fork of the Catawba River, at the foot of the Blue Ridge Mountains, and is but 1,350 feet above tide water, while 15 miles west, in an air line over the Blue Ridge, Mitchells Peak rises to an elevation of 6,711 feet above tide. The ruggedness of the country, the difference in climatic conditions, and the consequent diversity in agricultural interests can be appreciated when we consider that the highest part of the area is a mile higher than the lowest part. Some of the mountain slopes are so steep as to render their cultivation unprofitable, or in places even impossible, but all of these slopes and even the tops of the highest mountains are usually covered with a deep, rich soil, which is often held in place by a thick growth of original forest. On the plateau the cross chains are sometimes broken down, but there are no broad and well-defined valleys. Extending along the plateau east and west from Gillespie Gap to Cane River there is a depression formed by the breaking down of the cross chains. Viewed from an elevation it gives the appearance of a valley, though it is crossed by numerous streams and small ridges. The streams which cross this depression do so nearly at right angles, and go with an even flow through their narrow, winding valleys. Freshets are so frequent in these valleys that conditions are not usually favorable for the accumulation of sand and silt along the stream courses. The valleys are being cut deeper. The stream courses are strewn with rocks of all sizes. Near their source the rocks are large and angular, while farther down they become smaller and less angular. Where the mountain valleys are wide enough to favor the accumulation of sand and silt along the stream courses this "made" land is very valuable, and where there is enough of it it is usually the center of a settlement or township, as, for example, at Pensacola, in Yancey County.

There is an excessive amount of rainfall, as would be expected in such high altitudes, but the rugged features and difference in elevation assure good drainage. Every depression in the mountains has a small, sparkling, rapid-flowing stream. The Appalachian Mountains form the chief watershed in the eastern United States, so within the area a part of the rainfall eventually reaches the Atlantic through the Catawba River and a part reaches the Gulf of Mexico through the Mississippi.

In passing through the area one is greatly impressed by the difference in the fall of the streams which flow south and east and those which flow north or west. The former plunge down a series of cascades, through V-shaped gorges, often falling from 1,500 to 2,000 feet before they reach the Catawba River, a few miles below, while the latter, and especially the North and South Toe and Caney rivers, often

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flow miles without rough water, sometimes passing through narrow gorges, but more often flowing through smoothly rounded valleys.

It is along these latter streams that there are the greatest possibilities for the development of water power. There are already some small saw and feed mills. The volume of the North Toe and of the lower part of the Cane River is sufficient to furnish power for large manufacturing concerns. As yet the power has not been developed, because there were no railroad facilities, but with the completion of a railroad now being built these possibilities will probably be realized. The nearness of the new railroad to the river banks will in some cases interfere with the construction of dams, but there are several places where the fall is sufficient, where there is an abundance of water, and plenty of room for the construction of a dam, with a good building site for a mill and dwellings, and also where there would be comparative safety and freedom from freshets. The healthfulness of the climate is proverbial. There are plenty of people ready and willing to work, so the question of labor is not difficult of solution.

The rocks of the area are made up of various granites, gneisses, and schists. The granites vary from a coarse pegmatite variety to a fine-grained variety which can hardly be distinguished from a gneiss. The gneisses are mostly of the mica and hornblende variety. Besides these rocks there are some diabase and diorites, and in places considerable calcite. In the vicinity of Woodlawn there are large deposits of a calcite which takes a good polish.

A great deal of the rock in the area is of certain igneous origin. The gneisses and schists were probably of igneous origin, but have been so changed through metamorphism that it can not be said definitely.

Owing to the high elevation of the area, the amount of rainfall is necessarily great and the winters are long and cold. Disintegration is very rapid, and the steep mountain slopes, where they have not been deforested, and the tops of the highest mountains are usually covered with a deep soil. The original vegetation is very dense, and this has aided in holding the mountain soils in place. Deforesting the steep mountain slopes in Buncombe County, while profitable to the owners of the mills, has proved a great injury to the property owners along the stream courses in the low country. Freshets are more frequent, the slopes become gullied, and in time of high water the river-bottom farms in the low country are covered with sand and mud. This was especially true in the spring of 1901. With the cutting off of more timber the probability is that freshets will be more frequent and destructive.

The ruggedness of the country is largely due to the unequal rate of weathering of quartz, or rocks which contain a large percentage of quartz, and the feldspar and calcite rocks. The latter have weathered

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rapidly, and the streams have adjusted themselves to the more easily eroded places, forming valleys, while the quartz, or the rocks containing a large percentage of quartz, have resisted these agencies of degradation and stand up, forming the highest mountains.

SOILS.

The following table gives the names, area, and proportional extent of the soils of the area surveyed. Besides the five soil types shown by colors on the map accompanying this report, certain uncolored areas will be found. These represent rock outcrop, the extent of which is also given in the table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Porters clay	98,624	31.0	Meadow	6,976	2.2
Porters black loam	87,808	27.6	Rock outcrop (no soil)	5,184	1.6
Porters sandy loam	76,480	24.1			
Porters sand	42,816	13.5	Total	317,888	....

PORTERS CLAY.

The Porters clay is a clay loam or clay of reddish color, overlying a red clay subsoil. The soil varies in depth from 6 to 10 inches, the depth depending upon situation, whether in level areas or on the mountain sides. The subsoil often extends down several feet before disintegrated rock is reached. Occasionally there are large quantities of quartz scattered throughout the soil and subsoil.

This soil is not confined to any particular part of the area. The largest bodies of it, however, are found in those sections which lie between the higher mountain ranges and the low and rounded ridges. It is also found along the foothills of the higher mountains, and often extends up the southern slope of these a considerable distance. The largest continuous strip of this soil is found in the vicinity of Burnsville and Cane River. The rolling character of its surface assures good drainage. It is drained by the many small streams that rise in the mountains, and often also by the larger streams and rivers.

At one time the Porters clay lying on the north slopes and lower ridges of some of the higher mountains was probably covered by a black loam, but on account of clearing off the timber, cultivation, and washing, the covering has been removed, exposing the red clay below. (See Pl. X.)

The Porters clay is a residual soil derived from the weathering of granite, gneiss, and schist rocks. The range of temperature and abundance of rainfall during the year are so great in this mountain region that the underlying rocks disintegrate very rapidly, forming a deep, rich soil.

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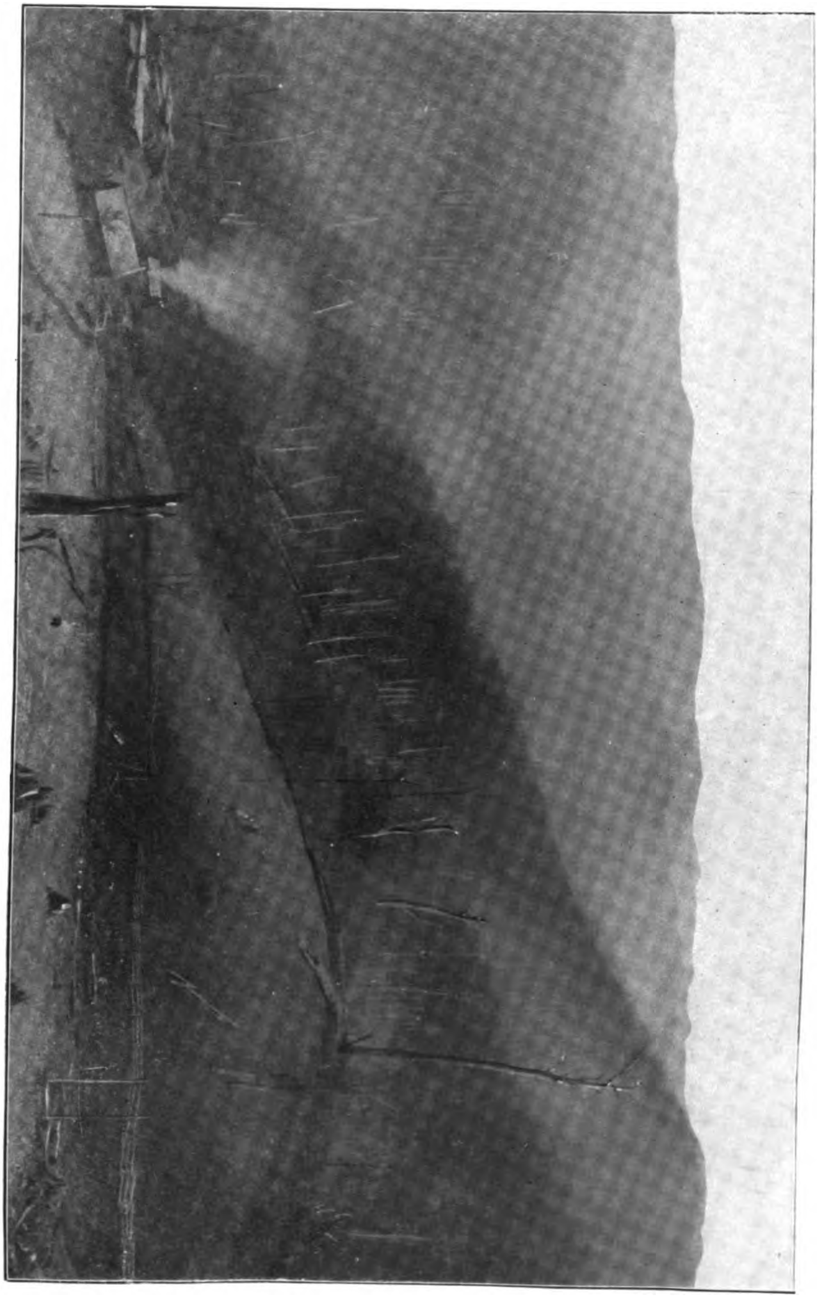

GENERAL VIEW OF THE MOUNT MITCHELL AREA, NORTH CAROLINA.

Showing the very mountainous character of the country, with the narrow valleys for general farm crops, but with numerous coves adapted to fruit farming.

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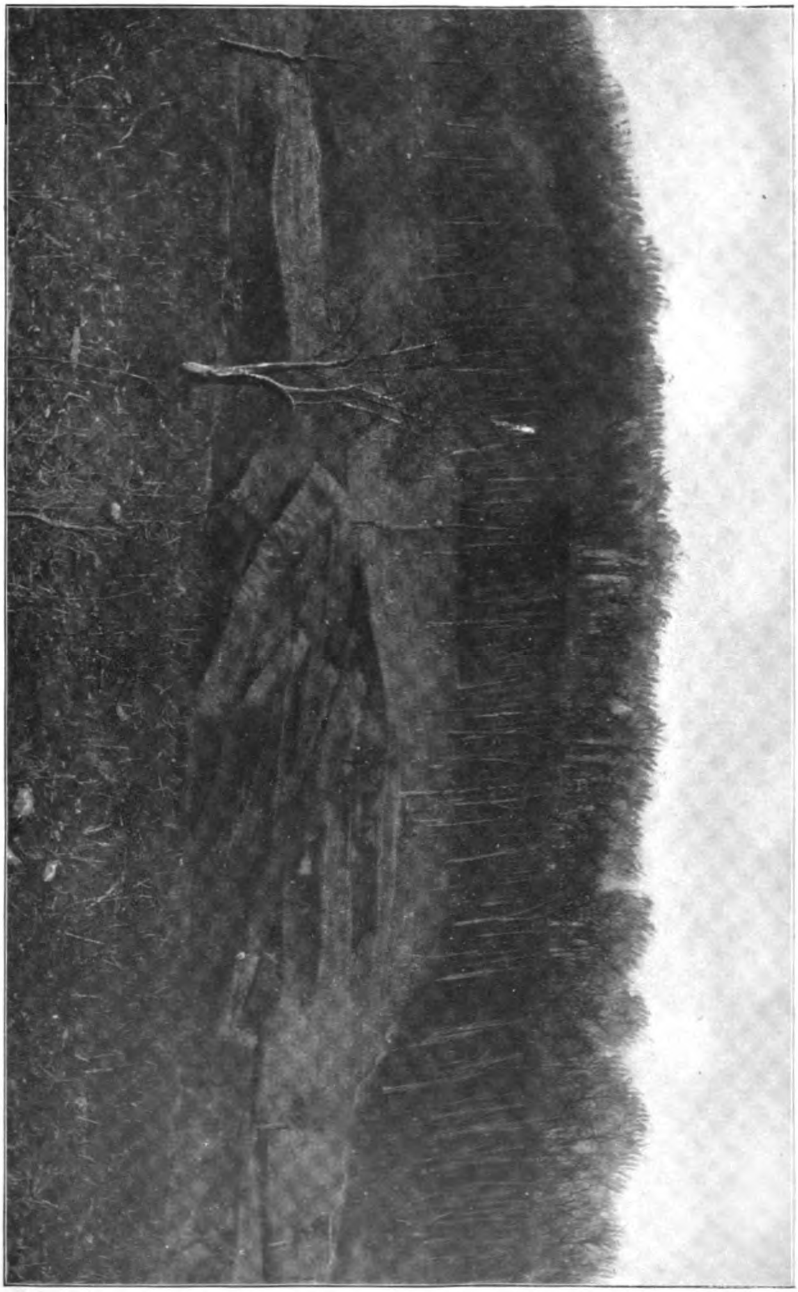

GULLIES IN PORTERS CLAY ON HILLSIDE WHERE CLEARED OF TIMBER, MOUNT MITCHELL AREA, NORTH CAROLINA.

With the large rainfall of this mountainous area, the steep slopes, and large drainage areas, the soils are very rapidly eroded after the forest is cleared.

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The location of this soil, together with its adaptability to all of the general farm crops of the area, makes it on the whole one of the most desirable soils in the mountains for general agricultural purposes. The principal crops are corn, grass, fruits, and wheat. Besides these, sorghum, Irish and sweet potatoes, and vegetables give good yields. The average yield per acre of corn is about 20 bushels; of wheat, about 10 bushels, and of oats, about 30 bushels. Sweet and Irish potatoes yield 200 bushels per acre when properly cared for. Cabbage, turnips, and other vegetables do very well. This soil is capable of a high state of improvement, and retains fertilizers for a long time. Wherever large continuous tracts of it are farmed the general appearance of the region indicates great prosperity. The Porters clay is a stronger soil than Porters sandy loam or Porters sand, and was among the first soils to be taken up when the country was settled.

Upon this type were seen growing some of the best apple orchards in the area. If it can be said that it is especially adapted to any particular crops, perhaps apples, corn, grass, and oats would have to be mentioned first, but every crop grown in the mountains does well upon this soil type without any particular attention.

The following table gives the mechanical analyses of this soil:

Mechanical analyses of Porters clay.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7715	Estatoe	Stony loam, 0 to 6 inches.	3.29	3.62	9.32	8.66	22.34	12.80	29.84	13.22
7717	Burnsville	Stiff, tenacious red clay, 0 to 7 inches.	1.10	3.96	9.24	8.00	19.88	9.60	15.06	32.72
7716	Subsoil of 7715	Stiff red clay, 6 to 36 inches.	.57	3.90	9.00	7.68	20.30	12.06	24.56	22.50
7718	Subsoil of 7717	Stiff clay, 7 to 36 inches.	.49	2.22	7.98	7.20	15.20	6.60	17.30	42.90

PORTERS SANDY LOAM.

The Porters sandy loam is a gray sandy loam, overlying a red or reddish-brown clay loam subsoil. The soil has an average depth of about 8 inches. Like the subsoil of Porters clay, the subsoil of this type is often very deep. There are often large quantities of quartz rock strewn on the surface.

This soil is found in one large body in the northern part of the area

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and in small patches throughout the area surveyed, except on the higher mountains. It is often found in small patches along the base of the higher mountains and in all locations on the lower mountain ridges and on the rounded hills of the plateau between the high ridges. Next to the Porters clay this is the most extensive soil type of the area.

The numerous small streams in the area and the elevated position of the type insure good drainage, but if not carefully handled the loose, sandy nature of the soil and the somewhat loose, fluffy nature of the subsoil of the type make it subject to washing and gullying. In some few places, where the top soil had been removed from large areas by washing, the soil had to be classed as Porters clay. In a few such places the fields have been abandoned because they are so badly gullied. When such is the case the farmers usually clear off new tracts near by.

This type, like the Porters clay, is derived from the weathering of granite, gneiss, and schist rocks. The sand and quartz rocks strewn on the surface and mixed with the soil and subsoil are accounted for by the greater resistance to weathering, characteristic of this material.

The Porters sandy loam is used for corn, wheat, oats, sorghum, fruits, and vegetables. In fact, it is used nearly as successfully for all purposes as the Porters clay. With proper methods of cultivation it seems better adapted to corn, sweet and Irish potatoes, and peaches than the clay soil, but it does not retain fertility as long, because the subsoil is more porous. To keep it in a high state of productiveness requires constant application of fertilizers. In many locations it would seem that the surface has a greater tendency to wash than has the Porters clay.

The average yield per acre of corn is about 25 bushels; of oats, about 30 bushels; and of wheat, about 8 bushels. Sweet and Irish potatoes, where given the best cultivation, yield over 200 bushels per acre. Potatoes seem to do especially well, being larger, sounder, and smoother than those grown upon the less sandy soils. Formerly some tobacco was grown successfully upon this soil, but now no attempt is made to grow this crop. If climatic conditions were right this would be an excellent soil for cotton. No cotton is grown within the area. In the vicinity of Democrat this soil is used to produce tomatoes to supply the local canning factory.

The table following gives the mechanical analyses of soil and subsoil of this type.

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Mechanical analyses of Porters sandy loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7727	Democrat	Grayish loam, 0 to 8 inches.	1.22	6.20	12.56	9.14	17.38	20.14	23.84	10.16
7725	Barnesville.........	Grayish-yellow loam or sandy loam, 0 to 8 inches.	1.48	6.04	12.40	9.22	17.04	18.38	25.26	11.54
7729	Pensacola	Grayish-yellow loam, 0 to 7 inches.	5.69	9.50	12.50	7.70	13.48	11.14	24.66	21.18
7730	Subsoil of 7729......	Reddish loam or clay loam, 7 to 36 inches.	1.05	6.64	10.86	8.68	16.52	13.20	28.26	15.46
7728	Subsoil of 7727.......	Reddish loam or clay loam, 8 to 36 inches.	.27	6.20	9.56	6.82	14.82	18.82	19.58	23.92
7726	Subsoil of 7725......	Reddish clay loam, 8 to 36 inches.	.70	8.04	10.56	6.50	11.60	9.92	22.84	30.76

PORTERS BLACK LOAM.

The Porters black loam is a loose, black loam, usually overlying a clay subsoil. It contains a large proportion of organic matter in different stages of decomposition and ranges in depth all the way from 6 inches to 3 or 4 feet. The subsoil is usually of a reddish color.

In the present area this type is found on all the high mountains, especially on those which have never been cleared and on which the slowly decomposing organic matter has been collecting for ages. The largest bodies of this soil are found in the mountains of the northwestern and southern parts of the area, but it is also found in smaller bodies in all of the mountains, and especially in the coves which are protected from the sun. In some of the lower mountains parts of the area which were formerly Porters black loam have been so badly worked and washed that they no longer have the characteristics of this type, but rather those either of Porters clay or Porters sandy loam, and in some few cases the surface has been so badly washed as to expose the underlying rock. In the mountains of Mitchell and Yancey counties the Porters black loam is the most extensive soil type, being found on the high ranges and in almost all of the coves. In these counties this soil extends nearer to the bottoms of the mountains on the north side than on the south side.

The elevation of the Porters black loam, together with its loose, porous nature, assures good drainage. Ordinarily the fertility of this soil is easily maintained, nor does the surface wash, but by improper methods of cultivation it has in a few places been so badly washed as

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to exclude it from classification under the type name. Above an altitude of about 3,500 feet none of the area has ever been under cultivation. As these high altitudes are cool and moist the conditions have always been favorable for the accumulation of organic matter derived from leaves, branches, fallen trees, and undergrowth. Hence by far the greater proportion of the region above an altitude of 3,500 had to be classed as this soil type; and since so large a part of the area surveyed is above that altitude the importance of the Porters black loam can readily be appreciated.

In the lower altitudes the possibilities of this type for fruit, especially apples, are being recognized. Several young orchards have been set out recently in the vicinity of Ball Mountain. It is upon this soil, in sheltered coves, that the Albemarle pippin has attained such perfection and famè in the Albemarle region of Virginia. Not many peaches are grown in the area, but they seem to do best upon this soil type.

The fertility and loose texture of this soil seem to adapt it especially to Irish potatoes. In parts of the area where the seasons are sufficiently long it grades next to the meadow land for the production of corn. It is as well adapted to timothy and clover as it is to apples, and for years it has been used as pasture land. It is especially well adapted to vegetables, celery and cabbage doing remarkably well.

This type has long been considered the richest soil in the mountains, and only its inaccessible location has prohibited its more general cultivation.

The following table shows the texture of the soil and subsoil of this type:

Mechanical analyses of Porters black loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7719	Oges Creek	Brownish-black loam, 0 to 12 inches.	11.63	5.32	12.36	11.50	22.46	7.74	30.62	10.00
7723	1 mile N. of Burnsville.	Loose, light loam, 0 to 10 inches.	15.97	4.10	15.08	13.00	23.38	6.64	25.18	11.38
7721	Mount Mitchell	Loam or sandy loam, 0 to 10 inches.	9.85	5.44	6.46	5.30	10.86	5.56	33.04	33.34
7720	Subsoil of 7719	Brown clay loam, 12 to 30 inches.	6.18	7.90	11.94	7.26	14.22	8.52	32.46	17.54
7722	Subsoil of 7721	Loam or sandy loam, 10 to 36 inches.	6.24	5.94	10.12	6.80	13.78	6.90	30.74	25.72
7724	Subsoil of 7723	Loam, 10 to 36 inches.	8.77	3.10	8.36	8.26	18.96	11.70	20.70	28.74

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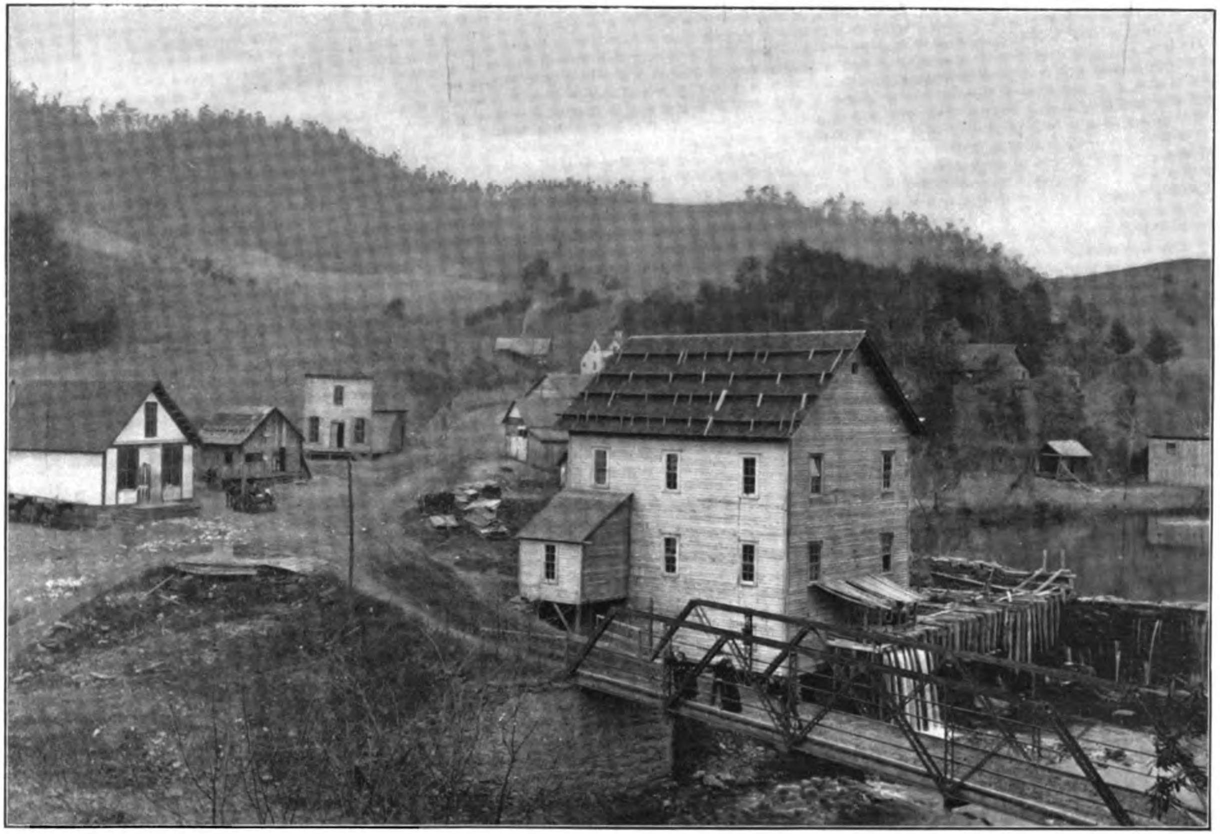

TYPICAL MOUNTAIN TOWN IN THE MOUNT MITCHELL AREA, NORTH CAROLINA, SHOWING THE NARROW VALLEYS AND ROUGH TOPOGRAPHY.

Unadapted to general agriculture on any extensive scale, but well adapted to fruit culture.

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PORTERS SAND.

The Porters sand is a light-gray sand or sandy loam with a coarse sand subsoil. The soil is usually a fine sandy loam varying in depth from 7 to 12 inches, while the subsoil is usually a coarse sand, often running into partially disintegrated rock and sometimes into solid rock. The parent rock is occasionally exposed at the surface.

This soil occurs in several parts of the area, but is found most frequently in the belt of mica-bearing rocks. The mica is found in the pegmatite granite belts. This granite is composed of comparatively large individual particles of feldspar, quartz, and mica. When these weather they break up into sand or gravel; hence the character of the Porters sand.

There are two large areas of this type, one on the Toe River northeast of Burnsville and the other in the vicinity of Sprucepine and extending northward toward Yellow Mountain. Porters sand is usually found on the lower ridges and foothills, and seldom on the higher knobs and peaks. The fact that both soil and subsoil are quite porous in nature assures good drainage.

As stated above, this type is formed mostly from the large individual particles of feldspar, quartz, and mica in the pegmatite granite. This granite weathers easily to great depths, breaking up into large grains. Those near the surface become further decomposed in time and are mixed with fine sand and organic matter, forming the soil over the loose, large gravel and rotten rock of the subsoil.

The most important mineral feature of the type is mica, which occurs in relatively large proportions. This considerable admixture of mica causes the Porters sand to be regarded as a poor soil. With proper cultivation and fertilization, however, nearly all of the general crops of the mountains do fairly well. Corn, oats, fruit, and vegetables are grown. The soil needs careful handling because of its porous nature, which allows added fertility to leach out readily. The average yield per acre of corn on this type is 15 bushels and of oats about 20 bushels. No wheat is grown upon it. Cherries and peaches do exceedingly well, while cabbage and turnips seem to do nearly as well. Some areas of this soil are used for pasturage, and it is said to support a very good growth of grass.

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The following table shows the texture of the soil and subsoil of this type:

Mechanical analyses of Porters sand.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7733	Crabtree Falls....	Yellowish sand, 0 to 12 inches.	1.33	10.54	24.68	12.50	21.26	6.02	7.40	17.00
7735	Sprucepine.......	Brownish-yellow sand, 0 to 10 inches.	4.04	11.88	15.50	9.76	18.00	8.14	14.36	21.60
7731	Wood Mountain..	Grayish-yellow sand, 0 to 8 inches.	3.23	15.64	15.60	7.14	12.90	5.40	17.36	25.34
7734	Subsoil of 7733....	Sand or gravelly loam, 12 to 36 inches.	1.05	33.20	28.84	13.72	17.84	4.92	3.96	6.60
7736	Subsoil of 7735....	Coarse sand, 10 to 36 inches.	.48	10.80	20.86	15.86	21.56	7.96	10.20	11.76
7732	Subsoil of 7731....	Loose, porous sand, 8 to 36 inches.	.26	13.44	21.70	8.98	18.18	6.26	12.32	18.32

MEADOW.

The Meadow soil is of heterogeneous origin and its characteristics vary so greatly in different places that no description can be given which would be typical of the areas in general. It is always found along the stream courses and is the accumulation of material left in the valley bottoms in time of high water.

The streams of the area are generally so swift and the valleys so narrow that the conditions for the formation of meadow land are not usually favorable. The character of the materials forming this type varies in different parts of the stream course. Nearest the mountains it is intimately mixed with angular rocks of all sizes, while farther down these rocks become smaller and less angular.

Where the valleys are wide deposits of finer materials are found farthest from the stream courses. The Meadow in such localities is the most valuable soil in the area, in some places having been sold for as much as $100 per acre. It was the first soil to be taken up when the country was settled. It is very well adapted to every crop suited to the area, but seems especially valuable as a corn and grass soil. The average yield of wheat is not large, but as high as 80 bushels of corn have been frequently grown upon it, and 1½ tons of hay per acre is not an uncommon crop.

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ROCK OUTCROP.

Certain areas on the accompanying map will be noticed as uncolored and marked by symbol. These areas are in the main either rock outcrop proper or so stony as to be entirely unfit for cultivation.

AGRICULTURAL CONDITIONS.

From the standpoint of agriculture this section of North Carolina is not so prosperous as the Piedmont country. The lack of development has not been due, however, so much to the lack of possibilities as to a lack of opportunities. The country was not settled as early as the more eastern parts of the State, and it is only in comparatively recent times that it has had any railroad facilities whatever. Formerly the railroads were so far away and the highways were so difficult of travel that it was not profitable to haul farm products to market. Live stock was the chief source of revenue, because the cattle could be driven to market. To this industry the comparatively mild climate, long growing season, and excellent grass are very favorable.

The possibilities of the area for the production of fruit and vegetables have been known for years among the natives. Apples, cherries, cabbage, and potatoes grew luxuriantly, but the lack of markets prevented the growing of these products on a commercial scale. Since railroads have come nearer, markets have opened up and farming has received a great stimulus.

It is found that apples do well anywhere in the valleys, due to the fact that the plateau has an average elevation of 2,500 feet, thus affording suitable climatic conditions. In the lower mountains it is found that apples do best in the rich black coves on the north side, while in the higher mountains, where it is much cooler, it is found that south coves are equally as good as the north coves, or perhaps even better.

None of the land above an altitude of 3,500 feet has ever been under cultivation. It can be said definitely that apples do well up to that height, almost regardless of location and kind of soil, but the black coves on the north side of the lower mountains and on the south side of the higher mountains seem best adapted to this fruit and afford the safest soils.

As to the possibilities of cultivation above 3,500 feet, nothing is known at present. Above an altitude of 5,000 feet the balsam fir comes in and the mountains are entirely covered with forests of this tree, presenting the same appearance as the mountains of northern New York and southern Canada.

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SOIL SURVEY OF THE ABBEVILLE AREA, SOUTH CAROLINA.

By F. W. TAYLOR and THOMAS D. RICE.

LOCATION AND BOUNDARIES OF THE AREA.

The area surveyed is the territory covered by the Abbeville sheet of the U. S. Geological Survey. This sheet includes the land lying between the parallels of 34° and 34° 30′ north latitude and the meridians of 82° and 82° 30′ west longitude. It is rectangular in shape, being about 29 miles in extent east and west and 35 miles north and south, and comprises about 1,006 square miles, or 644,160 acres.

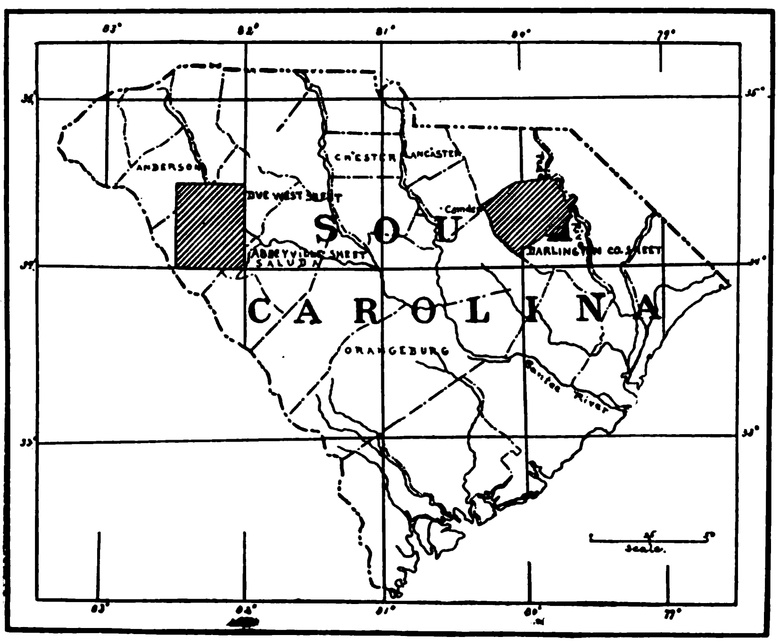

FIG. 6.—Sketch map showing areas surveyed in South Carolina.

Within the area are included about 400 square miles of Abbeville County, 380 square miles of Greenwood County, 170 square miles of Laurens County, and 50 square miles of Anderson County. The town of Laurens is situated in the extreme northeast corner of the sheet, and the village of Mount Carmel is just one-half mile west of the southwest corner.

As it was necessary to revise the road system to bring the base map up to date, the map has been redrawn and the contours omitted.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The territory covered by this survey was originally included in the old District of Ninetysix, which comprised the present counties of Abbeville, Greenwood, Laurens, Newberry, Edgefield, and Saluda, with the district court-house at Old Cambridge, where the "Star" fort is located and where the battle of Ninetysix took place.

The land upon which the present town of Abbeville is located was purchased from Gen. Andrew Pickens, who lived at Fort Pickens, near the "big spring," now within the corporate limits of the town. The town, however, was named after the town of Abbeville, France, by Dr. John de la Howe, who, emigrating from that place about 1765, had established a large plantation on Little River. The county of Abbeville was set off in 1800.

The earliest products which this part of the country gave to commerce were the skins and furs of wild animals. Between 1740 and 1750 the "cow-pen keepers" and "cow drivers," led here by the representations of the trappers, hunters, and Indian traders, built their cabins along the bottom pastures and made large inclosures, into which their numerous herds were driven for marking and handling. This business was quite extensive, and large numbers of cattle were annually driven to the markets of Charleston, Philadelphia, and New York. Horse raising was largely engaged in, and so highly were the qualities of the Carolina horse of that early day esteemed that a statute of the provincial legislature forbade the introduction of the inferior horses of Virginia and other plantations.

The region possesses just such features of climate, topography, soil, and vegetation as would attract and fix upon its hills and valleys the energetic race which was the first to clear away its forests and appropriate its vast agricultural resources. Consequently, around the "cow pens" of the stock drivers the agricultural settlers soon appeared.

The first settlement of this kind was made in 1756, near Calhouns Mill, by William and Patrick Calhoun, John Noble, and other hardy pioneers who had emigrated from Virginia. This settlement was composed of the best educated men and was perhaps the most thrifty and prosperous of any of the early ones. It was almost annihilated, however, in 1760, by an Indian massacre, which took place near Lower Long Cane Church.

The next settlement was made by a company of 200 French Huguenots, under the leadership of Rev. Jean Louis Gibbert, who landed at a place called Buford and marched overland to Bordeaux. A fort was built here and 60 acres were set off for each man's farm.

The third settlement of any importance was that of the Scotch-Irish

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Presbyterians, in the vicinity of Long Cane and Curltail creeks. This settlement grew very rapidly and at the beginning of the Revolutionary war contained nearly as many whites as in 1860.

The original forest growth was quite different from the forests of the present time. On the highlands the oak, hickory, and chestnut were of large growth and stood far apart. There was no underbrush and the woods were carpeted with grass and the wild pea vine. Along the streams and in the valleys the distinctive growth was willow, beech, birch, black walnut, ash, poplar, and gum. The cane also flourished best here, although it often grew upon the higher ground. The cane growth was the standard by which the early settlers estimated the value of the land. If it grew only to the height of a man's head, the land was esteemed ordinary, while a growth of from 20 to 30 feet indicated the highest fertility.

The principal early agricultural crops of this region were wheat, corn, hemp, and grapes, raised exclusively for home consumption. The cultivation of tobacco was also engaged in, but was restricted by the difficulty of marketing such a bulky article over the rough and poorly constructed roads. The tobacco was commonly packed in hogsheads, and with spindles fastened to the heads and shafts attached it was drawn, or rather rolled, to the Charleston market. Indigo, too, was one of the first commercial articles produced, but the raising of it has long since ceased, owing to cheaper production elsewhere.

The culture of silk worms was introduced to some extent by the early French settlers, and has been carried on in a limited way to the present time. Silk culture on a commercial scale for this region is now being agitated, and it would perhaps prove a thriving industry, as the mulberry grows to perfection here.

Not only the forests, but the cultivated fields as well, present a very different aspect now from what they did after the country was first opened up. It was then new and beautiful and as remarkable for the luxuriant richness of its landscape as it is now for the striking features of its rolling hills and long, narrow valleys. The original forest has disappeared almost entirely, and has been replaced by scrubby oaks, by underbrush, and by the shortleaf pines of the abandoned fields. The chestnut and chestnut oak have been dying out for the past sixty years, and the cane has likewise almost disappeared.

Since the introduction of cotton a century ago the system of farming has been greatly changed. Instead of raising cattle and horses and wheat and corn, as was once done, the culture of cotton has so superseded all other agricultural pursuits that the traveler might well be of opinion that no other crops could be profitably grown.

CLIMATE.

The shorter seasons and lower temperatures of the Piedmont region, as compared with those lying immediately south of it, are attributable

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in part to differences of elevation or of latitude, these differences being themselves slight. Other influences are proximity to the mountains, and still more the heavy clay soils and subsoils, more retentive of moisture and therefore colder and later in spring than the lighter sandy soils of the Coastal Plain. Cotton planting is about ten days later than in the lower country. Cotton also blooms later, but by a lesser period, and the same is true of the opening and picking season, showing that although it starts later it grows faster, passing more rapidly through its various stages to maturity.

The growing season in this area may be considered to be approximately seven and one-half months. Killing frosts in the spring are not expected later than March 22, nor in the autumn before November 10. The following table, compiled from the South Carolina section of the climate and crop service of the Weather Bureau, shows the normal monthly and annual temperature and precipitation at Greenwood, which is centrally located in the area. The figures are based on records covering a period of thirteen years.

Normal monthly and annual temperature and precipitation.

Month.	Greenwood.		Month.	Greenwood.	
	Temperature.	Precipitation.		Temperature.	Precipitation.
	°F.	Inches.		°F.	Inches.
January	41.8	3.76	August	78.6	5.52
February	43.1	4.89	September	73.4	4.56
March	53.5	4.31	October	62.3	2.78
April	61.3	3.91	November	52.4	3.04
May	71.6	3.80	December	42.7	3.24
June	78.8	4.13	Year	61.6	48.86
July	79.8	4.92			

PHYSIOGRAPHY AND GEOLOGY.

The area surveyed lies in the Piedmont region. The surface of the country is a gently undulating plain that becomes more rolling as it approaches the rivers and larger streams, and is finally broken and hilly above the bottoms and narrow low grounds through which the many water courses find their passage.

The region is well drained by these numerous streams, which have a marked parallelism of course from northwest to southeast. There are two systems of drainage: the one through the Saluda River and its tributaries to the ocean by way of the Congaree, and the other through Long Cane Creek and Little River by way of the Savannah. These two systems are divided by a watershed that extends in a southeast direction from Honeapath to Ninetysix.

The elevation of 16 different points in the area, ranging from 570 feet at Ninetysix to 896 feet at Craytonville, gives a mean elevation

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of 657 feet. The general rise in the surface from the southeastern to the northwestern corner is approximately 8 feet to the mile. The rise in the beds of the streams for the same distance is about the same, although their courses are marked by numerous shoals and small waterfalls. These waterfalls on the larger streams mark the sites of many gristmills now in operation and of many more that have gone to decay through lack of use since the growing of cotton has largely taken the place of grain. At Ware Shoals, on the Saluda River, for a distance of 3 miles the water comes tumbling over the granite rocks, which are so close together that a man can step from one to another. In this distance there is a fall of 68 feet, and plans are now nearing completion to build a $500,000 cotton factory on this site, and thus to utilize the enormous energy that has heretofore been literally running to waste.

The geology of this area is that characterizing generally the Piedmont region of the Atlantic slope, which extends from Maryland to Alabama. The rocks of igneous origin consist of granites, gneisses, and dioritic porphyries, and of metamorphic origin, of schists and slates. All these rocks represent the older portions of the earth's crust, and have been more or less altered in position and composition by the long-continued and subtle forces of nature.

The granitic rocks underlie by far the largest portion of the area. They are the basis of all the soils in the northern half of it. The dioritic porphyries come to the surface in three distinct and widely separated regions; i. e., in the vicinity of Calhouns Mills, between Gaines and Epworth, and 4 miles south of Hodges.

The schists and slates usually outcrop in dikes, but in the region of Kirksey the slates give rise to the soils over quite an extended area.

In but a comparatively small proportion of the area in this section is cultivation impeded by the rocks prevalent there. This is due to the remarkable extent and depth of the decomposition of these rocks. Wells dug to a depth of 30 or 40 feet require no implements for excavation except a pick and shovel. Frequently so thorough is the decomposition that the sides of railroad cuts might be mistaken for a heap of transported material did not the existence of seams and quartz veins, which may always be traced on the fresh surfaces, make it certain that the rock had rotted in place. The quartz veins vary in width from a few inches to several feet, but where even a small vein outcrops the surface is covered with the quartz fragments, or "flint rocks," as they are locally called, for perhaps 20 yards on each side, thus indicating that many feet of the original rock have been decomposed in the formation of the soil there found. Large bowlders of granite and "nigger heads" of diorite are frequently found scattered here and there. Why these rocks should not have been decomposed with the others is a mooted question, but it was probably because of

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some peculiar chemical or mechanical combination of the constituents which made the rocks more resistant to weathering agencies.

The mineral resources of the area are as yet largely undeveloped. Several manganese mines have been opened up during the present summer about 5 miles south of Greenwood. The ore was found to run in veins instead of pockets and to be of considerable extent, but it did not analyze quite high enough to be of commercial value with the necessary long shipments. Small amounts of iron, copper, nickel, cobalt, and pyrites are found associated with the manganese, but not in sufficient quantity to warrant the mining of them.

Gold-bearing ore seems to be pretty generally distributed over the area. In the vicinity of Little Mountain, south of Abbeville, several mines have been opened and some gold taken out, but a large percentage of the ore is not rich enough to be economically worked.

SOILS.

The soils of this area have been classified according to their texture into the following types: Cecil clay, Cecil sandy loam, Durham sandy loam, Iredell clay loam, and Davie clay loam. With the exception of the Iredell clay loam the types have a subsoil that is quite similar, being a very stiff, compact clay with a color varying from a dark red to a light yellow, and containing slightly varying amounts of sand and quartz fragments. The surface foot of these types, however, shows distinct and marked differences, and it has been largely upon this basis that the above classification has been made.

The soils are all residual, having been formed from the disintegration and decomposition of the rocks underlying them. In a general way it may be said that the sandy loams occupy the more elevated and more nearly level portions of the area, while the clay and clay loams are found on the slopes.

Areas of different soils.

Soil.	Due West sheet.	Abbeville sheet.	Total area.	Proportional extent.
	Acres.	*Acres.*	*Acres.*	*Per cent.*
Cecil clay	138,880	194,112	332,992	51.7
Cecil sandy loam	155,072	81,216	236,288	36.7
Durham sandy loam	21,440	6,400	27,840	4.3
Davie clay loam	....	25,856	25,856	4.0
Iredell clay loam	4,096	10,752	14,848	2.3
Meadow	1,856	4,480	6,336	1.0
Total	321,344	322,816	644,160	....

CECIL CLAY.

The Cecil clay is the characteristic red clay land of the Piedmont plateau. It consists of a red clay loam with a depth of 6 or 8 inches, underlain by a stiff, heavy reddish clay increasing in compactness with depth. Both the soil and subsoil contain some sand, and larger

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quartz fragments are found scattered through them to greater or less extent, depending upon the frequency of occurrence of the quartz veins in the decomposed rock.

The Cecil clay covers about 52 per cent of the area. In the southern half, especially in the region north and east of Abbeville, it largely predominates. It is usually found occupying slopes of varying declivity, the loose sand having been washed away as fast as it was released from the tenacious clay. A glance at the map will show that the Cecil clay very generally follows the stream courses, covering an area from 2 to 3 miles wide on each side of the streams in their lower courses and gradually diminishing in width as the headwaters of the streams approach the higher and less rolling areas of land. This fact is quite noticeable in the case of Long Cane Creek and Little River.

This soil is considered the strongest and most productive type of the area. It is more retentive of moisture than the sandy soils, and for this reason is better able to withstand seasons of drought, as is evidenced by the rich deep-green color of the crops growing upon it during such times. The surface has a tendency to dry and form a crust after rains, and this should be broken by cultivation as soon as possible to allow the young plants to push through, and to provide a mulch which may assist in preventing excessive evaporation of the soil water.

In the Abbeville area the Cecil clay is used chiefly for the production of cotton, yielding from 200 to 250 pounds of lint per acre. Corn yields range from 15 to 20 bushels per acre, wheat from 8 to 12 bushels, and oats from 18 to 24 bushels per acre. The cowpea does fairly well on this soil, but when the season is not too dry it grows better on the sandier lands.

The following table of mechanical analyses of this soil shows its composition:

Mechanical analyses of Cecil clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6975	1 mile S. of Ninety-six.	Reddish-brown loam, 0 to 8 inches.	0.74	4.86	13.88	10.92	21.56	16.54	14.86	17.88
6973	4 miles E. of Abbeville.	Reddish-brown clay loam, 0 to 8 inches.	.60	1.50	5.12	5.04	18.10	11.62	21.22	37.40
6976	Subsoil of 6975......	Friable red clay, 8 to 36 inches.	.33	.86	3.74	2.88	6.66	7.62	35.76	42.20
6974	Subsoil of 6973......	Red clay, 8 to 36 inches.	.20	.80	2.58	2.74	11.32	6.60	29.92	45.96

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CECIL SANDY LOAM.

The Cecil sandy loam consists of a brown or dark-gray sandy loam, from 6 to 12 inches deep. The sand is medium to coarse rather than fine, the rocks from which it is derived being usually coarse grained. The subsoil is red and very similar to that of the Cecil clay, but usually has more sand mixed with it, making it somewhat less compact. Quartz fragments are found scattered through both soil and subsoil.

The type is distributed over the whole area, although it is more prevalent in the northern part, which is less broken than the southern. It occurs in areas of varying extent, depending upon the topography. It usually occupies the ridges and the levels, having apparently been formed by the gradual separation of the siliceous and argillaceous material formed by the disintegration and decomposition of the underlying rocks. This has presumably been effected by a process of lixiviation, during which the rain water, owing to the general levelness of the surface, has not been carried off, but has percolated downward, carrying the finer clay particles with it through the interstices of the larger sand particles. These clay particles have a marked tendency to be held in suspension, as is shown by the general turbidity of the streams which cut through the clay soils.

On the slopes where the Cecil clay is found the sand, as well as a part of the clay, has been removed in the process of erosion by the falling rains. As might be expected, with the clearing of the land and the washing of the slopes the areas of the Cecil sandy loam are gradually decreasing, while the areas of the Cecil clay is proportionately increasing.

Owing to the easy cultivation of this type of soil it is often preferred to the Cecil clay, although in dry weather the cotton and corn grown on it show a tendency to "burn" much more quickly. The type is better adapted to cotton than to the grains. The average yield of cotton is from 175 to 225 pounds of lint per acre. Corn and wheat yield from 8 to 12 bushels, and oats about 15 bushels per acre. Peaches, plums, apples, and cherries grow very well both on this type and on the Cecil clay. The truck crops and tobacco would be well adapted to this soil, especially in the areas where the greater depth of loam occurs.

The table on page 281 shows the results of mechanical analyses of this type.

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Mechanical analyses of Cecil sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6977	2 miles NW. of Abbeville.	Brown sandy loam, 0 to 12 inches.	0.66	7.76	21.68	11.90	23.52	12.58	15.40	7.22
6979	2 miles NE. of Erwin's mill.	Sandy loam, 0 to 8 inches.	1.19	9.20	18.80	12.00	20.92	15.30	15.60	8.08
6980	Subsoil of 6979....	Red clay loam, 8 to 36 inches.	.52	5.00	9.56	5.52	10.66	7.12	21.84	40.30
6978	Subsoil of 6977....	Reddish clay, 12 to 36 inches.	.37	4.42	11.90	6.20	10.52	5.68	18.46	42.82

DURHAM SANDY LOAM.

The Durham sandy loam is the sandiest type of soil in the area. It consists of a grayish sandy soil 10 to 15 inches deep, the whole consisting of rather coarse material and the surface few inches being almost pure sand. The subsoil is a yellow or mottled clay containing some sand, but becoming heavier with depth. Quartz fragments occur in this soil with the same frequency as in the two soils already described. It is found in two comparatively large areas, one around Hodges and the other in the vicinity of Craytonville. Many areas of small extent also occur. It is usually confined to the higher level areas, but is frequently found adjacent to the streams in their upper courses. The soil has been derived from the coarser-grained granites and gneisses and other igneous rocks, and has been formed by a process similar to that set forth in the description of the Cecil sandy loam.

At the present time the Durham sandy loam is farmed almost exclusively to cotton and corn, yielding about 200 pounds per acre of the former and 10 bushels of the latter. Because of its extremely sandy nature it has a tendency to leach and is quite subject to drought. Cowpeas and sweet potatoes do quite well on it. Some very fine varieties of grapes are also grown on it, and the gravelly portions are well adapted to the growth of pear trees. It is typically a melon and bright-tobacco soil. The table on page 282 shows its texture.

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Mechanical analyses of Durham sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6985	5¼ miles N. of Abbeville.	Coarse gray sandy loam, 0 to 14 inches.	0.46	3.02	15.44	12.24	29.14	20.68	11.22	7.98
6987	1 mile SW. of Hodges.	Grayish sandy loam, 0 to 12 inches.	1.85	13.06	19.70	9.48	15.56	15.22	18.66	8.30
6986	Subsoil of 6985...	Mottled red and yellow clay, 14 to 36 inches.	.37	2.06	9.96	5.82	19.40	15.36	17.20	30.36
6988	Subsoil of 6987...	Yellowish clay loam, 12 to 36 inches.	.19	5.78	8.42	4.22	7.18	6.10	21.64	46.74

IREDELL CLAY LOAM.

The Iredell clay loam is what is locally known as "flat-woods" or "buckshot" land. The soil is a dark-brown loam, sometimes almost black, from 6 to 8 inches deep. In places it is quite sandy, and could almost be classed as a sandy loam. The subsoil is a yellowish-brown, stiff, very tenacious, waxy clay, grading into the undecomposed rock at a depth of about 4 feet. Small nodules of iron carbonate, which give rise to the appellation of "buckshot" lands, occur scattered through the surface foot of soil.

The Iredell clay loam is the product of the weathering of the dioritic porphyries, which are the heavy, dark-colored, and usually fine-grained rocks of the Piedmont region. Portions of these undecomposed rocks, called "niggerheads," are found scattered over the surface in considerable quantities. This soil is found in three principal sections of the area, where the parent rocks outcrop. Besides these three sections small, irregular patches occur in other places.

The flat, even configuration of the surface of this type, and the impervious nature of the subsoil, naturally interfere with drainage, an interference, however, not at all beyond remedy, as the fall for properly constructed drains and outlets is ample. Because much of this land requires drainage and is difficult to work it has in the past received little attention.

There has been a popular belief that this soil contained an excess of lime. To prove or disprove this, a sample was sent to the laboratory for a chemical analysis, and the results obtained as shown on the next page.

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Sample.	Calcium oxide.	Magnesium oxide.
	Per cent.	*Per cent.*
Soil, 0 to 7 inches	0.20	0.28
Subsoil, 7 to 36 inches	.32	.14

Neither sample effervesced with hydrochloric acid, so that it is certain that carbonates of lime or magnesia are not present in any appreciable amounts. The figures given for lime can not be regarded as excessive, as the content of many of our very best soils about equals these figures. The proportion of magnesia to lime, however, is somewhat higher than is customarily the case, but the absolute amount of either can in no way be injurious to plant growth.

This soil is better adapted to growing grain and grass than cotton, the latter having a persistent tendency to rust. Wheat, corn, oats, peas, and clover are grown with very fair results. Subsoiling on this land has proved very beneficial, the good results showing for several years afterwards. Its productiveness could be increased by improved methods of cultivation, thorough drainage, deepening of the arable soil by judicious plowing, and by the addition of a liberal supply of green manure or well-rotted stable manure to provide humus and improve the soil texture.

Mechanical analyses of Iredell clay loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6991	4½ miles NE. of Abbeville.	Sandy loam, 0 to 10 inches.	1.19	7.04	10.28	7.10	28.60	28.54	13.12	5.32
6993	4 miles S. of Hodges.	Grayish-brown sandy loam, 0 to 10 inches.	.67	6.24	8.28	5.12	19.84	23.74	27.74	9.14
6989	9 miles SW. of Abbeville.	Sandy loam, 0 to 7 inches.	1.08	7.24	16.26	10.48	21.06	15.06	14.28	14.76
6992	Subsoil of 6991	Stiff yellowish-brown clay, 10 to 36 inches.	.75	1.44	2.36	3.22	15.04	14.30	26.34	37.24
6990	Subsoil of 6989	Yellowish-brown sticky clay, 7 to 36 inches.	.81	.86	2.04	1.74	4.30	5.42	27.86	57.72
6994	Subsoil of 6993	Stiff waxy clay, 10 to 36 inches.	1.18	.76	1.86	1.48	5.18	7.08	22.12	61.64

DAVIE CLAY LOAM.

The Davie clay loam consists of a light-gray, fine, rather compact sandy loam, having a depth varying from 5 to 10 inches, beneath which

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is a reddish clay subsoil, quite friable to a depth of 30 inches on account of its content of fine sand. Below this depth the clay contains less sand and becomes stiff and compact. Quartz fragments from the smallest particles up to pieces as large as a man's head are associated with both the soil and subsoil.

The Davie clay loam, locally known as "white land," is confined to the southern half of the area, and occurs for the most part in long, narrow belts. It is derived from the talc schists and talcose slates that outcrop in numerous dikes. As these dikes have no regularity of outcrop, the soils have no uniform topography, but are found both on the ridges and on the slopes.

A somewhat different phase of this type is found in the vicinity of Kirksey, where on the more level areas, the soil has a slightly greater depth and a little finer and more silty texture. The subsoil has frequently a yellow color, though its textural difference is very slight. The soil of this phase of the type is derived from the soft talcose slates instead of from the talc schists.

The Davie clay loam has about the same value for cotton production as the Cecil sandy loam. Where the loamy soil has a maximum depth corn and oats seem particularly adapted to it, the large amount of fine sand and silt in the subsoil permitting the deeper penetration of the roots.

Below is given a table containing mechanical analyses of samples of this soil type:

Mechanical analyses of Davie clay loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6981	5 miles S. of Abbeville.	Grayish fine sandy loam, 0 to 7 inches.	0.58	2.88	5.82	4.40	17.52	48.06	12.84	8.18
6983	8 miles S. of Abbeville.	Fine sandy loam, 0 to 8 inches.	1.85	2.04	4.72	2.74	10.86	44.14	26.04	8.50
6982	Subsoil of 6981	Red clay, 7 to 36 inches.	.48	.60	2.02	1.80	9.60	31.10	15.32	39.50
6984	Subsoil of 6983......	Reddish clay, with fine sand, 8 to 36 inches.	.23	1.02	1.64	1.30	4.18	23.42	25.96	41.78

MEADOW.

Along nearly all the streams, both large and small, there are strips of bottom land varying in width from a few rods to a quarter of a mile. These lands have been formed from the material washed from the

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slopes above and deposited as sediment in the stream valleys. They have no uniform texture, but range from a coarse sandy loam to a fine clay loam. They are deep soils and very productive, and are usually planted to corn, which will yield as much as 40 bushels to the acre. Excellent pasture, consisting of Bermuda grass, crab grass, swamp grass, and lespedeza, or Japan clover, is also found in them.

Their cultivation, however, is very uncertain, and is becoming more so, owing to the frequent overflows to which they are subject. The stream courses are allowed to become obstructed by logs and brush and gradually fill up, so that every little freshet is liable to inundate these lands to the extent of injuring and often destroying the growing crops.

From careful measurements and observation the channel of the Saluda River is found to be filling up at the rate of 3 inches per year and those of the smaller streams at even a more rapid rate. The preservation of these fertile bottom lands is a question of no little importance to the land owners. It is thought that by a cooperative and systematic plan of keeping the borders of the streams clear of brush and trees and the streams themselves free from débris the destructive overflows could be largely prevented.

WASHING AND GULLYING.

The red clay soils of the Piedmont region have a marked tendency to wash and gully. This is due partly to their structure—compactness and fineness of the particles—which prevents the falling water from entering them, and more largely to the hilly character of the country. The washing is not so destructive of the fertility as it would be if the soils were not formed from the rocks rotting in place, thus including at every depth all the varied elements of the parent rock. Thus it happens that the earth from the bottom of deep wells, usually barren elsewhere, when spread over the surface is at once productive.

Where cleared land is neglected the washing soon begins, and in an almost incredibly short time it has become so gullied that cultivation can not be continued. These gullies are often 20 or 30 feet deep, with perpendicular sides. They are narrow and short, extending only to the bottom of the slopes. In several places gates have been hung at the lower end and the gullies used as night inclosures for stock.

Within the past fifteen years remedial measures for the washing of the land have been attempted, and have, in a large degree, proven successful. The most common practice is that of terracing the land on the steeper slopes and running horizontal ditches on the slopes of less declivity. These terraces and ditches can be laid off with an ordinary carpenter's level and straight-edge, but more rapidly and accurately with a surveyor's level. One man with the instrument, another with the rod, and a third with a hoe to mark the course of

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the ditch, can lay off from 15 to 20 acres a day. A team with a ditching plow can throw up the ditches on 8 or 10 acres a day, the number of ditches, of course, depending upon the steepness of the slope. The average total cost for ditching should not exceed 50 cents per acre. The ditches should have a slight fall toward both ends, and should always be kept in good repair. Intelligently made, the ditches have been very successful, but unskillfully made, they often do more harm than good. The hillside terrace or ditch systems, with their method of contour or horizontal cultivation, together with the introduction of grasses whose roots have a tendency to mat and bind together the soil particles, will ultimately prove the salvation of much land that would otherwise be wasted.

AGRICULTURAL METHODS.

The system of farming has few variations. One principal crop is grown, and that is cotton. The fields are plowed and cultivated almost entirely with one-horse plows, the use of the turning plow and subsoiler being practically unknown. The heavy clay lands are seldom stirred below a depth of 5 inches. This is unfortunate, as deep plowing would establish more thorough drainage and form a better seed-bed. Deeper plowing is not practiced because such treatment is considered too expensive, the work animals and implements not being adapted to such cultivation of the heavy clay lands. The present demand is for light lands of easy tillage, whose recognized deficiency of fertility may be at once supplied by the use of commercial fertilizers. The aim is simply to supply the food needed by the growing crop, with little or no view to permanent improvement of the land.

The use of barnyard manure is very limited; so few cattle are kept and so little fodder and straw grown that what little manure is made is used on the garden patches, and the general field application of it is not thought of. The use of commercial fertilizers, however, is extensive. A complete fertilizer generally proves more profitable than one containing only one or two of the constituents, and the home mixing of these is found to be the most economical. Acid phosphate, kainit, guano, and cotton-seed meal are the forms generally used. The proportions of these are largely determined by their relative cost. It is customary for each farmer to make his own formulas, and apply the fertilizer at a rate to meet the demands of his land. An average mixture consists of 1,000 pounds of acid phosphate, 400 pounds of kainit, and 600 pounds of cotton-seed meal. This is applied at the rate of from 200 to 400 pounds per acre. For use on the clay lands, which are usually not so deficient in potash, the amount of kainit is somewhat decreased.

Fifteen to twenty years ago the growing of grains—corn, oats, and wheat—was quite extensive and profitable, the yields being then nearly

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double what they are now. The present low yields are ascribed to seasonal differences, but the true cause is more likely due to the poor structural condition of the lands resulting from the long-continued cropping of cotton.

The corn leaves are usually "pulled," tied in small bundles, and allowed to cure in the field. Later the ears are shucked and the stalks left standing on the ground. The great wastefulness of this method is beginning to be appreciated, and the custom of cutting and shocking the fodder, thus saving the whole of the plant for feed, is gradually being adopted.

The rotation of crops is nowhere reduced to a system. The land is planted in cotton for four or five years and then sown to grain, usually corn and cowpeas, the latter being planted in the row and cut and dried for hay after the corn is harvested. Wheat and oats are sown in the fall and harvested about the 1st of June; the stubble ground is then sown to cowpeas, which ripen before frost. The clean culture of the cotton leaves the land free from weeds, and after one season's crop of small grain is taken off the culture of cotton is resumed. The ratio of the price of cotton to that of wheat and corn determines more than anything else the succession of crops.

Fallowing forms no part of the system of culture. The "old fields" are preferred in many instances to the woodlands, and are being cleared of the short-leaf pine which covers them and replanted. The wood is used for fuel, either at the cotton gins or is sold to the cotton factories for about $1.20 per cord, delivered. These lands produce fairly well and require less fertilizer than the cultivated fields. One of the principal reasons for abandoning these lands in the first place was the gullies produced by the unskillful use of the plow and the general absence of methods of preventing the washing of the soils.

AGRICULTURAL CONDITIONS.

The same general lines of agricultural operations have been carried on in this area since the time of its first settlement. There have been periods when one set of conditions has brought about some changes in the usual practices, but these changes have been slight and of short duration.

General farming, it may be said, has always been the vocation of the rural classes. This is because the soil and climate, the natural factors in the development of an agricultural community, have been most conducive to that form of agricultural industry.

As the civil war wrought great changes in the social and economic conditions of the country, the agricultural conditions were likewise greatly affected. The "old prosperity" of antebellum days has been gradually replaced and superseded by a more general prosperity and material advancement of all the classes of people. The development

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of manufactures, the spinning of cotton especially, creating quick, steady, and remunerative markets for the diversified products of agriculture, is giving to the farmers advantages which they have never before possessed.

The farming lands as a rule are divided up into tracts of from 300 to 500 acres. These tracts are usually owned by individual farmers, and constitute what is called an average-sized farm. There are some old estates comprising 3,000 or 4,000 acres, but these are being gradually divided and sold. Many of the white owners, especially in the vicinity of the towns, live upon their farms and personally superintend the working of them; others rent them to responsible planters, who have their care and management.

Practically all the farm labor is colored, the negro tenants living in cabins scattered here and there over the farms. The average-sized farm will have five or six of these cabins. The labor of the colored men is of average efficiency. They can withstand the heat much better than the whites, but to get the maximum amount of work out of them requires the constant oversight of the "boss."

The rents are of two kinds, share rent and "money" rent. Under share rent the landlord furnishes the team, implements, seed, half the fertilizer, house, garden patch, and fuel, and the tenant furnishes the labor. The crops are then divided equally. When money rent is taken, the landlord furnishes nothing but the land and receives 2 bales of cotton, equivalent to about $75, for every 30 acres cultivated. This seems very high rent, considering that the value of the lands is quoted at only $7 to $10 per acre.

The system of farming is largely on the "extensive" rather than the "intensive" plan. This is but the natural consequence, however, of the character of the labor and the cultivation of one crop to the general exclusion of all others. Cotton planting has become so easy and simple, it requires so little individual thought and effort, and the money returns are so direct and certain, and every business, trade, and industry accessory to the work of the farmer has become so systematized and organized in unison with this pursuit that the introduction of new crops and new methods is very difficult.

Red clover and alfalfa have been grown to some extent on the Cecil clay, and both have produced very well. Peanuts, melons, and sweet potatoes are grown with profit on the sandy types. The cowpea, which is indigenous to this region, is profitably employed as an adjunct to the fertilizers used, and also to improve the physical condition of the soil. The extended use of this legume can not be too strongly urged, nor can the use of more manure and better methods of tillage, as substitutes for commercial fertilizers, be too strongly recommended.

The transportation facilities of the area, so far as railroads are concerned, are ample. One line crosses it from east to west, another

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from north to south, and a third from northwest to southeast. In no part of the area does a farmer have to travel more than 10 miles to reach the railroad.

The main public roads follow the ridges, thus avoiding the streams and the maintenance of numerous bridges. The roads of Anderson and a part of Greenwood County are kept in better condition than those in other parts of the area.

All the roads are dirt roads. In the summer these are very good, but during much of the winter the farmer is mud bound and unable to reach his market except with a maximum of expenditure of time and effort. If the labor of the short-term convicts now employed in the construction of dirt roads was intelligently utilized in permanent road building with the use of macadam, the results in the end would be far more beneficial. There are plenty of rocks found in nearly every locality, which if crushed would furnish excellent road material. It is a happy coincidence, too, that in the "flat-woods" regions, where the roads become the nearest impassable, the materials for road making are the most plentiful.

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SOIL SURVEY OF THE DARLINGTON AREA, SOUTH CAROLINA.

By THOMAS D. RICE and F. W. TAYLOR.

LOCATION AND BOUNDARIES OF THE AREA.

The Darlington area lies northeast of the center of the State, with the Pedee River as a boundary on the east and Lynchs River on the west, and has an extent of about 600 square miles. The area includes what was formerly Darlington County, but a part of it is now Lee County. Darlington, the county seat of Darlington County, has a population something more than 3,000. The smaller towns of Hartsville, Societyhill, and Lamar are included within the area. (See fig. 6.)

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

When first known to the colonists the present area of Darlington County was a heavily timbered forest inhabited by a number of feeble Indian tribes, among whom the Cheraws maintained a supremacy until the advent of the more aggressive Catawbas from the North. The two nations seemed to have effected a peaceful alliance, but although they always remained friendly to the white man they soon succumbed to the diseases and vices of civilization.

Many years passed before the settlers along the South Carolina coast established settlements very far inland, other than mere trading posts for barter with the Indians. Finally the advance of settlement began along the navigable rivers with rich alluvial bottoms. Every inducement was held out to these pioneers. The Welsh of Pennsylvania and Delaware were regarded as especially desirable settlers. They made their first settlement about the year 1736 near the present town of Societyhill on land granted them by the council. The settlers from the lower country—French Huguenots, Scotch-Irish, English, and Germans—soon followed. In numbers the Welsh predominated, but race characteristics were soon blended and lost.

The bottom lands along the Pedee River were first brought under cultivation, for besides their proximity to the river, then the only means of transportation, the Welsh considered this type of soil better adapted to their agricultural purposes. They met with disappointment, however, in their attempt to profitably cultivate hemp and flax,

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for neither soil nor climate was favorable to these crops. With wheat and corn they were more successful. The country afforded rich pasturage also, and the capture and sale of the cattle and hogs, which ran wild, early became a source of wealth. This region was for a time celebrated for its exportation of meat and breadstuffs.

About the year 1747 the culture of indigo was introduced, and for half a century, or until it was supplanted by cotton, it was the principal money crop of the region. Parliament allowed a bounty on all indigo exported to England, and fortunes were made in its production.

After the Revolution there began a new era in the agricultural history of this region. The cultivation of cotton on a large scale was begun. Negro slaves were found indispensable in clearing the land and performing the rough labor required by this crop. Social conditions also underwent a change. The early planters had established themselves near the river, but the growing unhealthfulness of the lowlands induced a removal to points along the old Camden road, which follows the sandy ridge from Societyhill to Camden. Their wealth increased rapidly and was largely invested in slaves. The large plantations were independent communities, producing within their borders nearly everything that they needed. Any surplus, together with the cotton produced, was shipped to the coast. Pole boats and small steamers engaged in such transportation plied regularly along the Pedee River.

The civil war and the scarcely less destructive period of reconstruction completely changed these conditions. The emancipated slaves were thrown upon their own resources, without the knowledge and self-reliance essential to successful agriculture. Compelled to rely upon the white man for assistance and advice, they gradually drifted into the present tenant system. Cotton became the principal crop. With the increase in production came a decrease in price. Many prominent planters of the old régime, who were broken in fortune and unable to adapt themselves to changed conditions, left the country.

When new methods had been adopted to meet the new conditions, and when confidence had been fully restored, there was inaugurated an era of progress and prosperity which has continued to the present day. There is every indication that this state of things will continue, for the agricultural possibilities of the county can not be fully realized for many years to come.

About 1887 the cultivation of bright tobacco was attempted, with such success that the acreage has rapidly increased and the returns have been most satisfactory. The advantages derived from the cultivation of cotton and tobacco, instead of cotton alone, are fully demonstrated to the farmer and will no doubt lead to a further diversification of crops.

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CLIMATE.

The following table, compiled from the records of the Weather Bureau, shows the normal monthly and annual temperature and precipitation for the Darlington area. These records were kept at Societyhill, in the extreme northern part of the county, and at Florence, which is only a few miles south of this area, so that they represent average conditions throughout the county:

Normal monthly and annual temperature and precipitation.

Month.	Florence.		Societyhill.	
	Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	Inches.	°F.	Inches.
January	43.5	2.54	43.0	3.30
February	47.7	5.13	45.3	4.68
March	55.9	2.90	55.6	3.35
April	62.0	2.61	62.2	4.45
May	72.8	3.78	70.9	3.04
June	79.1	5.44	77.2	5.37
July	81.1	5.93	78.5	6.15
August	80.1	5.97	77.4	6.05
September	74.7	3.82	72.9	4.25
October	63.2	2.91	61.8	3.56
November	56.3	2.45	53.1	2.54
December	43.6	2.46	45.7	2.78
Year	63.2	40.92	61.9	49.52

The area has a mild, agreeable climate, with sufficient rainfall to favor a wide diversity of crops. The maximum precipitation occurs during the summer months, while the other months have a fairly uniform distribution of rainfall. There is a gradual change of temperature from winter to summer, with no great excesses of either heat or cold. The average date of the last killing frost in spring is March 27 and of the first in fall November 15, although within the last nine years killing frosts have occurred as late as April 21 and as early as October 30.

PHYSIOGRAPHY AND GEOLOGY.

Darlington County lies wholly within the Coastal Plain division of the Atlantic seaboard. The present land area has been built up by the sediments which the rivers have brought down from the mountains and deposited on the old sea floor. These deposits were elevated, reworked by wind and wave action, and finally reached their present position as unconsolidated strata of sand, gravel, and clay. Geologically speaking, the surface formations of this area are of recent deposition and none date back of the Pleistocene period. The strata, which dip toward the southeast about 20 feet to the mile, cover the crystalline rocks to a depth of from 500 to 700 feet.

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Advantage has been taken of this stratigraphy in sinking artesian wells over a large part of the county. Abundant water is secured at a depth of from 100 to 250 feet. The water nearly always overflows at the surface and in some cases rises to a height of 8 feet. This water is, as a rule, slightly impregnated with iron and sulphur, but when the people become accustomed to its use it forms a most convenient and healthful water supply. In some cases the overflow might be profitably utilized in irrigation.

The Pedee River, which forms the eastern boundary of Darlington County, receives the drainage of the greater part of the area. This river is navigable with difficulty, and before the advent of better transportation facilities it was the only avenue by which the products of this section could be carried to market. No shipping is now done by river. Lynchs River forms the western boundary of the area and drains a smaller proportion of it. Black Creek, the largest tributary of the Pedee, traverses the entire length of the county. This creek, as well as several smaller creeks, furnishes power to run a number of small grist and saw mills. The streams occupy broad, shallow valleys and normally have a narrow strip of swamp along their borders. Many small streams, which become so swollen during heavy rains as to require bridging, become completely dry during short droughts.

There are three distinct surface features within the limits of this area. Along the Pedee River, and to a lesser extent along Lynchs River, are low-lying flat bottoms, with an elevation of only a few feet above the normal river level. Such areas are poorly drained and subject to overflow at every slight rise of the river. The Pedee River pursues a winding course through these bottoms, with the horseshoe bends common to rivers in broad, level flood plains. At slightly higher elevations are successive well-marked terraces of comparatively recent formation. Occasionally heavy rains may cause the flooding of the lower terraces, where no protective dikes have been constructed, but the upper terraces have been left by change of base level above the line of possible danger of overflow. The soils on these broken slopes vary greatly in texture, but are chiefly silty loams and heavier than the soils found elsewhere in the area.

The second division, according to surface conditions, covering the central and greater part of the area, consists of the gently rolling plateau of the uplands, broken by small stream valleys. Here are found the sands and sandy loams which constitute the best cotton and tobacco soils.

The third division includes the ranges of hills which occupy the northern and western parts of the county. These hills, from Societyhill to Clyde, are covered by a loose, leachy sand. Between Clyde and Lynchs River the Orangeburg sandy loam is developed. There is little change in topography, except what is due to the rapid erosion of

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the latter type. These lands have a low agricultural value, and only small tracts have been brought under cultivation.

SOILS.

Ten distinct soil types have been recognized and mapped in the Darlington area. The following table shows the extent of the various soils:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Goldsboro compact sandy loam	118,208	30.8	Selma heavy silt loam	15,488	4.0
Norfolk sand	71,104	18.5	Swamp	14,144	3.7
Norfolk sandy soil	65,024	17.0	Orangeburg sandy loam	9,984	2.6
Sandhill	30,656	8.0	Orangeburg loam	6,592	1.7
Sassafras loam	26,880	7.0	Total	383,680	....
Ayden fine sandy loam	25,600	6.7			

NORFOLK SAND.

The Norfolk sand is composed of 3 feet or more of coarse to medium sand containing a small percentage of silt and clay. In this locality the soil, which has an average depth of 9 inches, is darker in color than its subsoil, owing to a small admixture of organic matter, and for the same reason it is of a more loamy nature. The subsoil to a depth of more than 3 feet consists of a loose reddish-brown sand.

There are three principal areas of Norfolk sand in the Darlington area, although it occurs in many smaller patches and in association with nearly every other soil type. One broad band fringes in a general way the lowlands along the Pedee River. In the vicinity of Montclare the type becomes much finer in texture and gradually changes to the Ayden fine sandy loam. Another strip of Norfolk sand holds the same relative position along Lynchs River. The third and largest development extends as a belt along Black Creek in its course through the county as far up as Hartsville. It attains a width of several miles in some places, but the average width is less than 2 miles. North and west of Hartsville it merges into the extensive sand-hill formation which reaches to the county line.

The Norfolk sand occurs on rolling hills and stream slopes and at almost any elevation. The drainage is naturally good, except in a few small areas where swamps have been filled in by this sand.

The yield of cotton and corn on the Norfolk sand, as might be expected, is light. (See Pl. XIII.) A fair quality of tobacco is grown in places, but this is not regarded as the best soil for this crop. Potatoes do well, but are not grown in large quantities.

While the Norfolk sand is the typical truck soil of the Atlantic seaboard, it is not utilized for that purpose by the farmers of this

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locality. The successful production of vegetables for home use and to supply the local markets has demonstrated the possibilities along this line. Fair profits might be realized in growing truck early in the season for the Northern markets, and later for canning on a commercial scale.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Norfolk sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7846	1 mile E. of Darlington.	Loose brown sand, 0 to 9 inches.	1.15	10.52	25.68	13.08	23.94	14.60	6.94	4.50
7844	2 miles SE. of Montclare.	Loose sand, 0 to 8 inches.	1.18	2.84	13.98	17.48	43.08	9.60	5.94	6.94
7845	Subsoil of 7844....	Loose sand, 8 to 36 inches.	.43	3.20	15.12	21.98	39.58	9.26	4.84	5.06
7847	Subsoil of 7846....	Loose yellow sand, 9 to 36 inches.	.25	14.60	23.40	12.50	23.24	13.64	6.84	5.44

GOLDSBORO COMPACT SANDY LOAM.

The Goldsboro compact sandy loam is the most extensive and important soil type of the Darlington area. The surface soil is an ashy-gray sandy loam, 10 to 20 inches in depth. There is usually a slight stickiness and coherency in this sand which distinguishes it from the oil of the Norfolk sand. The subsoil is a tenacious and rather impervious clay loam, varying in color from yellow to dark gray. At lower depths the subsoil becomes lighter in texture. The line of contact between soil and subsoil is well defined. With the shallow plowing practiced in this section the subsoil is never disturbed.

This soil is well distributed over the central and southern parts of the county. Large, uniform areas are found between Darlington and Hartsville. The characteristic position of this soil is on the level, plateaulike stretches of the uplands. It rarely extends down to the borders of the streams, but usually gives place to the Norfolk sand or to the Norfolk sandy soil.

In the more level situations the drainage is apt to be poor, but from its elevated position the drainage of this land by means of shallow ditches is easily accomplished. Large tracts of this type which were formerly covered by standing water during rainy seasons have been reclaimed by this simple means. (See Pl. XII.)

The soil supports a natural growth of pine, oak, and hickory. In

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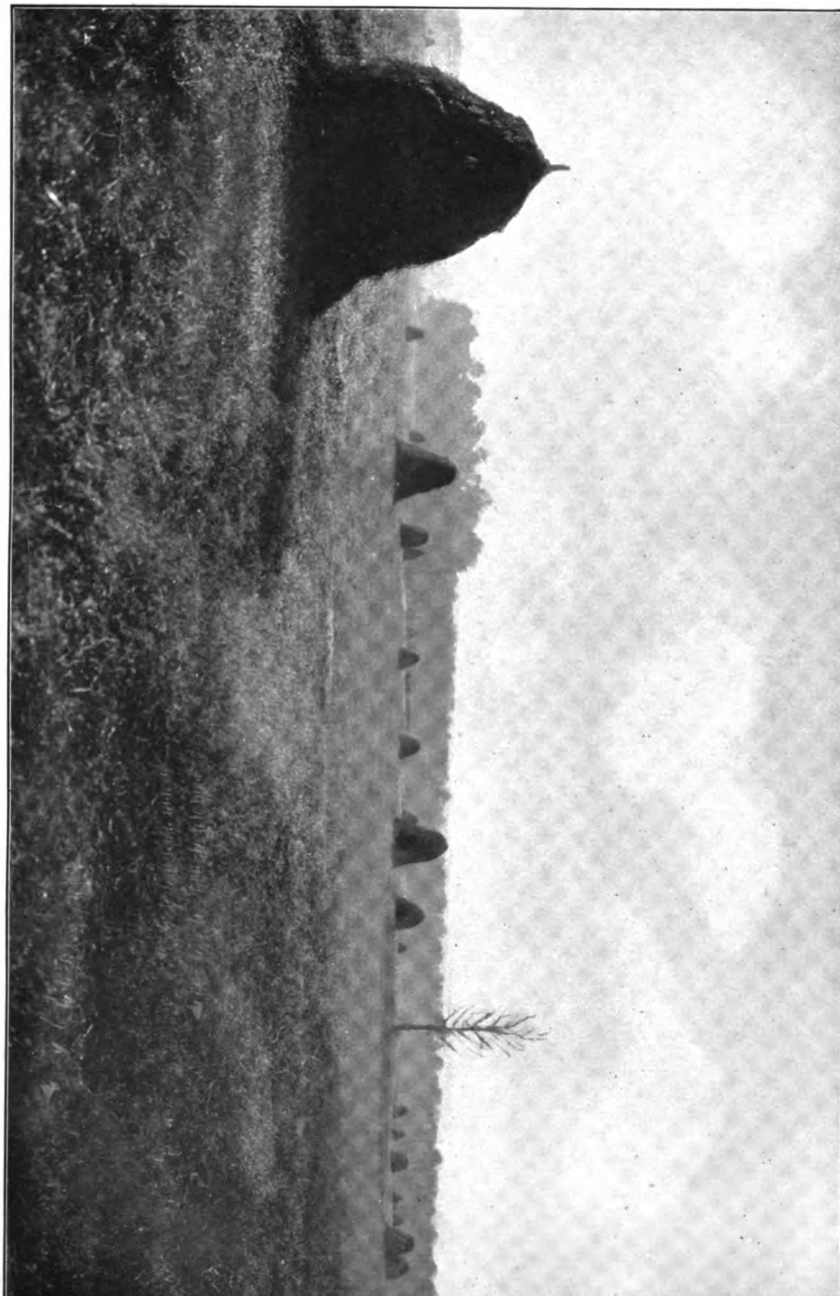

A CROP OF PEA-VINE HAY UPON THE GOLDSBORO COMPACT SANDY LOAM, DARLINGTON AREA, SOUTH CAROLINA.

This is one of the most valuable forage crops and soil renovators of the country.

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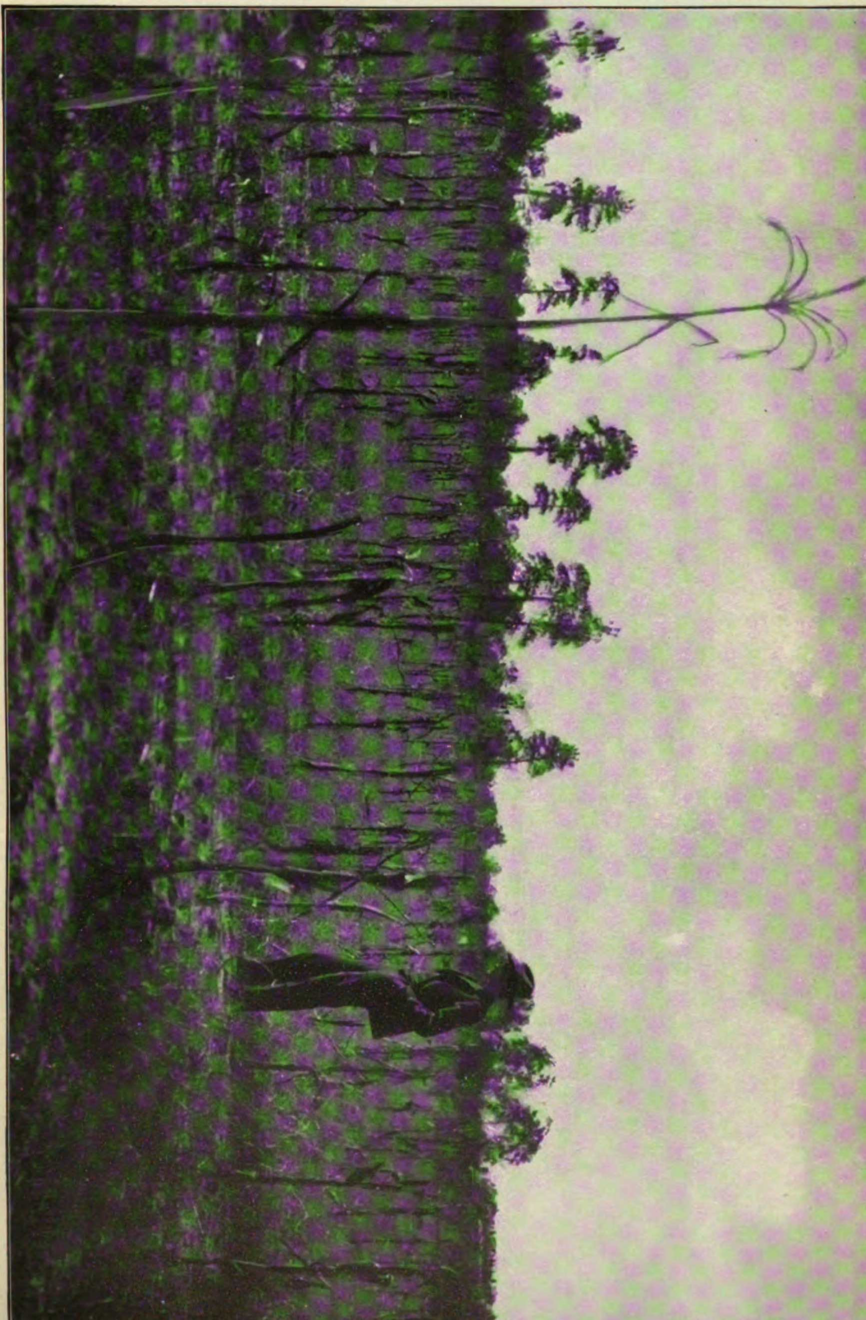

CROP OF CORN ON THE NORFOLK SAND, DARLINGTON AREA, SOUTH CAROLINA.

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poorly drained areas the black and the sweet gum flourish. The greater part of the cultivated areas are devoted to cotton and corn. Cotton, when properly cultivated, should produce three-fourths of a bale per acre, but the average yield is about one-half bale. This soil is too heavy to be considered a bright-tobacco soil. Grapes are grown to perfection, but only for home use. The Scuppernong variety does especially well.

The following table shows the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Goldsboro compact sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7838	Lamar............	Sandy loam, 0 to 10 inches.	1.11	6.60	21.74	13.50	20.06	16.26	14.36	7.42
7836	½ mile S. of Darlington.	Sandy loam, 0 to 12 inches.	1.55	8.20	24.82	13.20	18.14	12.58	11.42	11.30
7837	Subsoil of 7836....	Stiff yellow clay, 12 to 36 inches.	.50	4.24	17.80	11.46	16.80	10.60	12.38	26.54
7839	Subsoil of 7838....	Heavy clay loam, 10 to 36 inches.	.44	5.80	15.68	9.34	12.84	10.00	13.50	32.72

NORFOLK SANDY SOIL.

The Norfolk sandy soil consists of from 12 to 24 inches of a gray sandy loam, not unlike the soil of the Goldsboro compact sandy loam. A superficial examination might not suffice to distinguish the two types, but the subsoil gives rise to a variation in crop production which is quite evident. This subsoil is a sticky yellow loam or clay, which contains enough medium and fine sand, however, to render it much more friable than the subsoil of the Goldsboro compact sandy loam.

There are a few areas of this type bordering large sand tracts, but its normal occurrence is as a narrow border, varying in width from one-half mile to 2 miles along the smaller streams. As the stream is approached the sandy soil becomes deeper and the subsoil lighter in texture.

On account of the position of this soil the drainage is perfect. The uncleared areas support a heavy growth of pine and the various hard woods common to the uplands of this section.

While the Norfolk sandy soil is not as strong a soil as several others in the area, it has for the past few years produced on the whole more wealth for its owners. It is the bright-tobacco soil of the area, for although there are other soils of less extent which surpass it in the

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quality of the leaf produced, yet the bulk of the crop is produced on this type. While the subsoil is not so heavy as to thicken the leaf, it conserves moisture and eliminates the danger from an ordinary drought. The yield of tobacco is from 700 to 1,200 pounds per acre, but the best tobacco growers do not care to force the yield over 1,000 pounds, as the increase in quantity is at the expense of quality. The price realized for this tobacco varies, according to quality, from 5 to 65 cents per pound. The average price is 10 cents. From $150 to $200 is frequently realized on an acre of tobacco. Cotton does not yield as heavily as on the stronger types of soil. One-half bale per acre may be produced by the methods usually employed. Corn and cowpeas are grown to some extent.

The following table shows the mechanical composition of this soil:

Mechanical analyses of Norfolk sandy soil.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7842	1 mile NW. of Copeland.	Sandy loam, 0 to 14 inches.	0.61	8.36	21.74	13.34	20.00	16.96	13.06	6.32
7840	2¼ miles E. of Darlington.	Medium to coarse dark-gray sand, 0 to 9 inches.	.98	4.10	27.74	15.54	33.20	5.78	6.74	6.74
7843	Subsoil of 7842....	Sticky sandy loam, 14 to 36 inches.	.20	5.90	18.30	14.04	19.78	12.84	13.06	15.62
7841	Subsoil of 7840....	Sticky, compact yellow sandy loam, 9 to 36 inches.	.55	2.70	20.32	10.92	23.78	4.44	5.16	31.88

AYDEN FINE SANDY LOAM.

The Ayden is a very fine sandy loam 10 to 20 inches deep, overlying a fine, sticky, yellow loam subsoil. There is no sharp division line between soil and subsoil, but one gradually merges into the other. The top soil may contain a small percentage of coarse sand, but there is always a sufficient proportion of very fine sand and silt to give it the properties of a mellow loam, and in the heavier phases there is a slight stickiness in the soil even quite near the surface. The subsoil becomes heavier and more tenacious with depth for more than 3 feet. The physical properties of the soil are still further improved by the abundance of organic matter which it usually contains. On account of its superior retention of humus the improvement of this land by the incorporation into it of vegetable matter, such as the legumes, is more readily accomplished than with the other soils of the area.

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The largest extent of this type is found between Dovesville and Montclare. It occupies the rolling slopes as well as the level areas and varies slightly both as to texture and agricultural value. It is bounded on both sides by extensive areas of Norfolk sand and the transition line between the two types is not clearly defined. Other areas of the Ayden fine sandy loam are found near Palmetto, between Alcot and Stokesbridge, and near Cypress. The soil of the last-mentioned areas contains more coarse sand, but the subsoil is typical. This soil is well cultivated, the yields are most satisfactory, and it is recognized as the best cotton land in the area.

The Ayden fine sandy loam is largely devoted to cotton and corn. Corn, when properly tilled, may yield 35 bushels per acre. The best farmers expect a 500-pound bale of cotton per acre, but the general average is less than three-fourths of a bale. Cowpeas do especially well and are extensively grown on this soil. The usual plan is to sow peas between the corn rows and to cut the vine for hay after the corn has been harvested. About 1 ton per acre is the average yield of pea-vine hay.

While the Ayden fine sandy loam is not a good, bright tobacco soil, there is one phase of it which is so well adapted to this crop as to deserve special mention. The several areas of this phase are unfortunately quite small, and hence it was not practicable to map and describe them as a separate type. The soil is a fine, dark, sandy loam, 7 inches deep, mellow and easily tilled, underlain by a fine, lighter-colored sand to a depth of more than 3 feet. The sand becomes slightly sticky at the lower depths, but the usual heavy subsoil of the Ayden fine sandy loam is not reached. Small patches of this phase occur near Palmetto and in the vicinity of Montclare, inclosed by the typical Ayden fine sandy loam. The tobacco grown here is conceded to be superior to the leaf grown elsewhere in the area. About 100 pounds of commercial fertilizer are applied to an acre, and the addition of a few loads of stable manure is quite beneficial. A yield of more than 1,000 pounds per acre is not desired. The product of an acre has brought as high as $350.

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The following table shows the results of mechanical analyses of several samples of Ayden fine sandy loam:

Mechanical analyses of Ayden fine sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7825	1 mile SE. of Stokesbridge.	Gray fine sandy loam, 0 to 8 inches.	0.67	3.28	12.06	9.50	20.48	18.34	30.46	5.66
7827	½ mile N. of Montclare.	Loose dark-brown, fine sandy loam, 0 to 7 inches.	2.08	.62	4.88	7.10	29.48	29.42	22.02	6.20
7832	1 mile W. of Riverdale.	Dark fine sandy loam, with fine sand, 0 to 12 inches.	.88	1.60	14.68	15.04	42.64	8.04	8.78	8.38
7828	Subsoil of 7827....	Fine sandy loam, 7 to 36 inches.	.31	1.38	10.36	12.94	32.88	22.86	16.00	3.82
7826	Subsoil of 7825....	Heavy, yellow fine sandy loam, 8 to 36 inches.	.39	4.30	10.96	8.00	16.86	15.24	28.88	15.76
7831	½ mile N. of Montclare.	Sticky, yellow fine loam, 20 to 36 inches.	.49	.84	4.66	6.64	28.64	25.22	8.80	24.56

SANDHILL.

The Sandhill soil is an incoherent white sand about 4 inches deep, overlying a yellow sand of the same texture, which has a depth of 10 feet or more. The soil never contains enough organic matter to influence its physical condition. Along stream channels and in deep cuts there outcrops a loosely cemented sandy material which seems to render the soil still more unproductive wherever it approaches the surface.

The Sandhill formation is one of the most extensive and uniform soils of this region. The area included within the limits of this survey is but the edge of a vast sand ridge which covers a large tract in South Carolina and the neighboring States. This area, which stretches from near Greenplain in an almost unbroken extent westward as far as Clyde, is 12 miles in length and has a maximum width of 5½ miles.

The topography covered by this type consists of a series of long, high ridges or hills. (See Pl. XV.) The natural vegetation is a sparse growth of pine and scrub oak. One of the first roads in the State—the old Camden road—was laid off along this sandy ridge, no doubt on account of the ease with which a road could be made through these open woods.

Attempts to cultivate the Sandhill have met with little success, on account of the insufficient amount of moisture and plant food retained by the leachy sand.

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The following analyses show the texture of this soil:

Mechanical analyses of Sandhill.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7862	2 miles SE. of Fields Bridge.	Loose sand, 0 to 4 inches.	0.77	5.92	37.52	29.04	19.76	2.54	4.74	0.28
7863	Subsoil of 7862....	Loose sand, 4 to 36 inches.	.50	5.38	32.24	28.52	23.06	3.64	3.36	3.80

ORANGEBURG SANDY LOAM.

The Orangeburg sandy loam has at present a low agricultural value. The soil is composed of 8 to 20 inches of sand, with an average texture similar to that of the Norfolk sand. East of Ashland and along the borders of the Sandhill the soil resembles the latter type, being loose and leachy. The subsoil is always a characteristic red clay loam, usually grading into a compact sandy material which closely resembles that underlying the Sandhill. At a depth of from 12 to 20 feet white sand is struck, which makes well curbing necessary. The clay loam stratum of the subsoil varies from 2 to 10 inches in thickness. While the underlying compact material is somewhat indurated, it is porous enough to allow the percolation of water and friable enough to be broken by the plow without great difficulty. The Orangeburg sandy loam differs from the other types in the area in its gravel content. Both soil and subsoil contain from 10 to 40 per cent of waterworn pebbles, which rarely exceed the size of a man's thumb.

This type is confined to a compact area in the extreme northwestern corner of the county, extending from Clyde to the lowlands along Lynchs River. It occupies the same topography as the Sandhill, except that the surface has been cut and roughened by the rapid erosion to which this soil is subject.

The greater part of this soil is as yet uncleared. There is a good timber growth of both pine and the hard woods. This type of soil, under the present cultural methods, is not very productive. Wherever the hillsides are cleared and the soil is broken up washing and gullying go on so rapidly that the land is worthless after one season. On the more level and sandy tracts small yields of cotton and corn are secured.

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Mechanical analyses of this soil are given in the table below:

Mechanical analyses of Orangeburg sandy loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7851	¼ mile S. of Ashland.	Light sandy loam, 0 to 20 inches.	0.68	5.24	18.34	15.86	31.46	13.66	7.80	7.02
7852	Subsoil of 7851....	Sticky red clay, 20 to 36 inches.	.37	5.00	14.70	11.12	23.96	13.92	12.10	18.94

ORANGEBURG LOAM.

The Orangeburg sandy loam and the Orangeburg loam are locally referred to as the "red lands," on account of the color of their subsoils, but the latter type is far superior in productiveness, being one of the strongest soils in the Darlington area. It consists of a loose, dark loam, with a depth of from 8 to 15 inches, underlain by a sticky red clay. The soil contains a considerable percentage of small, smoothly-worn gravel and iron concretions, which tends to improve its texture.

The most extensive area of this soil occurs around Ashland, in the northwestern part of the area.

This land is highly esteemed for general farming. The usual selling price is from $40 to $60 per acre, and sales have been reported at $75 per acre. Cotton, corn, and oats are the principal crops grown. Cotton yields 1 bale per acre with proper cultivation. Sixty bushels of oats per acre have been harvested, but 30 bushels is perhaps nearer the average.

Mechanical analyses of this soil are given in the table following:

Mechanical analyses of Orangeburg loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7848	2¼ miles W. of Clyde.	Gray sandy loam, 0 to 8 inches.	1.65	9.50	20.70	13.30	22.60	15.36	6.44	11.56
7849	Subsoil of 7848....	Sticky clay, 8 to 20 inches.	.62	8.24	14.00	7.56	11.16	6.92	4.92	46.34

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SELMA HEAVY SILT LOAM.

The soil of the Selma heavy silt loam is a gray sandy loam rarely more than 6 inches deep, resting upon a heavy, stiff clay. This subsoil is gray or mottled in color, and in some localities of especially poor drainage it is discolored by iron stains.

This soil is typically developed in long, irregular, depressed areas, where the natural drainage is imperfect. Such tracts are usually covered by standing water during periods of excessive rainfall. Much of this land may be reclaimed by artificial drainage, but there are some areas which are worthless, even after a considerable expenditure in ditching, because of the compact, lifeless character of the soil. An illustration of this is to be seen in the case of the Cypress swamp, 2 miles northwest of Fields Bridge. Under the slavery system this swamp was cleared and drained by a deep canal, but the land proved so unproductive that it was cultivated only a very short time.

The Selma heavy silt loam is for the most part left to a dense growth of gum, cypress, hickory, and pine. On the cultivated portions one-half bale of cotton per acre may be made. Corn and sugar cane also do fairly well.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Selma heavy silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7860	1 mile SW. of Lamar.	Sandy loam, 0 to 6 inches.	1.32	3.78	10.66	7.08	12.62	9.30	31.36	25.16
7861	Subsoil of 7860....	Stiff clayey or silty loam, 6 to 36 inches.	.59	3.90	11.06	7.34	11.94	5.02	29.46	31.10

SASSAFRAS LOAM.

The heaviest soil found in the Darlington area is the Sassafras loam. It consists of a very fine brown sandy loam 4 to 6 inches in depth, underlain by 24 inches or more of silty clay loam, reddish yellow in color. This true subsoil is sometimes underlain by masses of very tenacious clay interspersed with thin layers of sand.

This soil extends as a wide border along the Pedee River from Societyhill southward, and has a maximum width of more than 5 miles within a bend of the river known as Robbins Neck. It occupies the series of terraces which intervene between the river and the uplands. The lower terraces are only a few feet above the normal level of the river. As might be expected from their position in the bends

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of the river and from their slight elevation, these lower bottoms, which comprise more than half of this type, are subject to overflow at any time from the floods that rush down from the Piedmont. It is an undisputed fact that these floods are increasing in volume and destructiveness every year, as the forests along the headwaters are devastated. Before the civil war slaves were employed in constructing dikes to protect these bottoms, but since that time as the dikes have been broken by the strong currents they have not been renewed.

The lands included within this type are wholly alluvial in origin, and from the standpoint of the geologist they are of very recent deposition. The upper terraces are composed of sediment left by comparatively still waters during overflows of the Pedee River when the channel of the stream was much higher than at the present time. On the lower bottoms the process of deposition is still going on.

Only a few square miles of this soil about Robbins Neck is under cultivation, the remainder being covered by a dense forest of such valuable timber trees as the cypress, pine, and hickory. The less desirable gum, beech, and oak also flourish. Several lumbering plants, the largest of which is located at Lumber, are rapidly exploiting these forests.

The Sassafras loam is well adapted to the purposes of general farming. It is the typical corn and wheat land of the area. Fifty bushels of corn per acre and 25 bushels of wheat can be made. One-half bale of cotton is the average yield per acre. The possibilities of this soil have not been realized, as the average farm tenant does not understand the treatment of a heavy soil. On the lower bottoms the danger of a total loss of crops has also to be taken into consideration. As only two good crops out of three, on an average, are harvested, the value of the land is greatly depreciated and extensive farm operations are effectually discouraged.

The following analyses show the composition of the Sassafras loam:

Mechanical analyses of Sassafras loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7855	1 mile E. of Lumber.	Fine sandy loam, 0 to 6 inches.	0.99	0.74	2.22	2.42	29.56	36.08	24.20	4.78
7858	¼ mile NW. of Robbins Neck.	Silty loam, 0 to 8 inches.	.69	.58	.90	1.70	32.46	30.06	21.48	12.70
7856	Subsoil of 7855	Brown silty loam, 6 to 20 inches.	.46	.34	1.74	2.16	20.02	22.48	38.46	14.72
7859	Subsoil of 7858	Heavy silt or clay, 8 to 36 inches.	.85	.26	.52	1.90	23.88	20.40	28.28	24.76

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TYPICAL SCENE IN TOBACCO WAREHOUSE IN DARLINGTON, SOUTH CAROLINA.

The bright tobacco, one of the important crops of the area, is hauled in open lots and placed in piles, representing different grades, on the warehouse floor, and sold at auction.

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CHARACTERISTIC VIEW OF THE SAND HILLS IN THE DARLINGTON AREA, SOUTH CAROLINA.

Soil is a very loose, coarse sand, hardly producing any crop and covered with a sparse growth of dwarf oaks and pine.

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SWAMP.

Along Lynchs River and many of the smaller streams of the county are low-lying lands, varying in width from a few hundred yards to one-half mile. The soil is a mixture of sands and silts, which have been washed down from the surrounding hills. It is only slightly elevated above the normal stream level, and is partially covered with standing water during the greater part of the year.

No attempt is made to cultivate these narrow strips. They are for the most part covered with an almost impenetrable growth of cypress, gum, and other water-loving trees and plants.

AGRICULTURAL METHODS.

While some of the Darlington County farmers are far above the average in intelligence and progressiveness, there are many who are slow to adopt new methods and to attempt cultivation of new crops.

The methods in vogue here for the cultivation of cotton do not differ materially from those in use throughout the State. As is usual in a sandy country, shallow plowing is practiced. Except in a few rare instances there has been no attempt to carry out any systematic crop rotation, although corn is sometimes alternated with cotton. The farmers should give more attention to this important subject. Under the present system the constant cropping to cotton makes a heavy, continuous demand upon the valuable fertilizing elements of the soil, and unless some return is made to the soil the yield rapidly decreases. To supply this deficiency of available fertility, commercial fertilizers are employed on all the soil types of the area. The rate of application for cotton is from 400 to 1,000 pounds per acre.

While tobacco has been grown only a few years, the most approved methods of cultivating and curing the bright leaf in use in other sections have been introduced here and are generally well understood. The farmers might well study more closely the adaptability of their several soils to this crop. Tobacco requires the most careful fertilization. One thousand pounds of a good potash fertilizer is generally used. The use of stable manure for any crop on these soils is decidedly beneficial, but only a small quantity is so used. The application of lime to these soils has not resulted in any marked benefit. There is a constant increase in the acreage of cowpeas, and their great value both as a feed and as a fertilizer is conceded. This crop can not be too highly commended, for as a forage crop it is the only substitute for the clover and timothy of the heavier soils. It has not been found advisable to plow under the mass of green vines to supply the soil with nitrogen. The better plan is to cut the vines for hay and allow only the roots, which contain a high percentage of nitrogen, to remain in the soil.

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AGRICULTURAL CONDITIONS.

The conditions which prevail among the farming classes of Darlington area at the present time are those of a transition from a state of depression to one of confidence and prosperity. The former status was the result of the disadvantages of a one-crop system of farming on a credit basis, enhanced by the distrust engendered by social and political changes. The cultivation of another money crop, tobacco, has put the agricultural community on a more independent basis, and the farmers of good management can now make and save money.

Of the 4,000 farms in this area less than one-third are operated by the owners. The plan of farm management generally practiced is the share-tenant system. The landowner furnishes the land, the work animals, the fertilizers, and the farm implements, and in return receives one-half the crop at the time of sale. The tenant, usually a negro, secures provisions for himself and family from the town merchant, whom he makes secure by a mortgage on the remainder of the crop. Owing to the great risk which he takes the merchant must add a large margin of profit on such credit sales, and as a result the tenant has little to show for the year's work after these and minor creditors are satisfied. If an exceptional crop should put him in possession of a surplus it is almost invariably squandered, and he begins the new crop year in debt. The profits of the landowner under this system are not large when all things are considered. The farm expenses with such a tenant are large. Moreover, the owner must keep all farm work under constant supervision, especially those operations demanding skill, as the harvesting and curing of tobacco. He also rests under the moral obligation of contributing to the support of the tenant in case of sickness or a failure of crops, which still further reduces his average of profit. There is a gradual betterment of these conditions. The more shiftless of both races are moving into the towns. The percentage of pay tenants is on the increase. Under the pay-tenant system the renter usually promises a certain amount of cotton in payment for the use of the land which he cultivates, and the owner does not share in the loss in case of a failure of crops.

The size of the farms ranges from a few to several thousand acres. There are about twenty tracts in the county which contain more than 1,000 acres. As a rule these large holdings lie along the Pedee River and include much uncleared and uncultivated land. The average size of farms for the whole county is less than 70 acres. While some large plantations are increasing in size, it may safely be asserted that there is a tendency toward a decrease in the average size of farms, and that these farms are now more generally operated by their owners.

Scarcity of labor is likely to give the farmer of this section some anxiety in the near future. The only labor available for farm work is negro labor, and the supply is fast becoming inadequate to meet the

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demand. The negroes are leaving the country for the towns, where employment at better wages can always be obtained. The pay of a negro man for farm work is commonly 50 cents a day, or from $7 to $10 a month. This labor is of only average efficiency. The negro may be intrusted with the mere mechanical cultivation of cotton, but in the labor requiring skill and the exercise of judgment, as the growing and curing of tobacco, he is of little service except when under constant supervision. The cotton crop is usually picked by "task," the standard rate of pay for this work being 40 cents per 100 pounds of seed cotton. Both women and children take part in the cotton picking.

The agricultural interests of the Darlington area center about cotton and tobacco. The other products are merely incidental to the cheaper cultivation of these crops. The half-million bushels of corn harvested annually in the county allows only one bushel to each animal kept on the farms, and grain must, therefore, be imported. Ten years ago cotton was the sole reliance of the farmer for an income. About 30,000 bales were produced in the county. At that time only 200,000 pounds of tobacco were produced in the entire State. Now the crop of the Darlington area alone is about 8,000,000 pounds. (See Pl. XIV.) Thus, without decreasing the yield of cotton, another crop is put on the market, and one which almost equals the value of the cotton crop and has a much larger margin of profit. This should encourage still greater diversity of crops. The other crops, which are grown on a smaller scale, are wheat, oats, cowpeas, sorghum, and sugar cane. The production of fruits is an industry that has been neglected. The sandier soils seem well adapted to peaches, but their cultivation has scarcely been attempted. A few small pear orchards have shown the possibilities of success with this fruit. Pecan groves yield well and are quite profitable.

The two lines of railroad which intersect at Darlington furnish transportation for the exports of the area. A short branch road connects Hartsville with one of the main lines. The most urgent need of the area is for a better system of roads. Fortunately, this may be secured at a comparatively small cost. The clay found near the surface of the sandy loams, when spread over the deep sandy roads makes a very satisfactory roadbed. Some of the main roads have been improved in this way, either by convict labor or by the voluntary cooperation of the community.

The bulk of the cotton crop is hauled to town for sale, after the numerous county gins have separated the lint from the seed. Several cotton-oil mills furnish a market for the seed, and a small part of the lint finds a market at the two local cotton mills. The bulk of the tobacco crop is handled by three warehouses at Darlington and one at Lamar. There are also markets, which handle a minor part of the crop, in the adjoining counties within easy reach of the Darlington farmer.

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SOIL SURVEY OF PERRY COUNTY, ALABAMA.

By R. T. AVON BURKE and PARTY.

LOCATION AND BOUNDARIES OF THE AREA.

Perry County is situated in the central western part of Alabama, and lies between 32° 15′ and 32° 52′ north latitude and 87° and 87° 30′ west longitude. The county is of irregular shape and is bounded by Bibb County on the north, by Chilton and Dallas counties on the east, by Dallas County on the south, and by Marengo and Hale counties on the west. The towns of Marion and Uniontown lie within its borders. (See fig. 7.)

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The first visit of white men to the present State of Alabama took place in July, 1540, when De Soto entered the State at the northeastern border with a large expedition. From narratives of this invasion we learn that the native Indian tribes were comparatively well advanced in agriculture, their sown fields reaching from one village to another along the rivers. They also stored their crops for winter use in rude barns and in other ways were considerably ahead of the tribes inhabiting the country farther north.

The Creeks and the Cherokees were the principal Indian tribes, and they, together with the Chickasaws and Choctaws, continued to hold a part of the lands until 1830, 1832, and 1838, in which years, by treaties with the National Government, they ceded their lands to the United States and were removed to Western reservations. In this way a source of much irritation to the settlers and of no little hindrance to the growth of the country was eliminated.

In March, 1819, the enabling act for the admission of Alabama into the Union was passed, and at the first general assembly under the constitution, convened at Huntsville on October 25 of that year, Perry County was formed.

The early agricultural products of the county were principally indigo, tobacco, corn, rice, and cattle. Cotton is not mentioned as an article of export, but by 1772 was grown to some extent, and machines for separating the lint from the seed at a rate of about 70 pounds per day were then in use. Several gins were established in different parts of

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the State in 1802. Almost from the first settlement of the county cotton has been the chief crop. It has been grown on all the different types of soils.

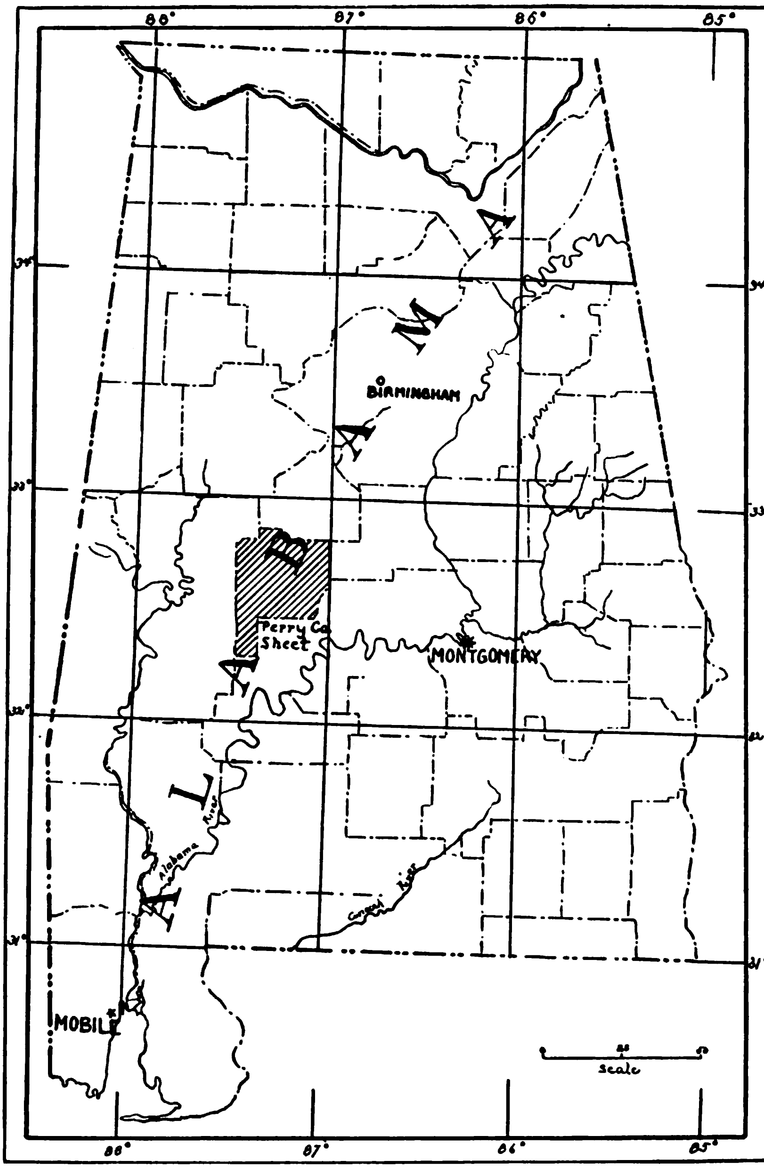

FIG. 7.—Sketch map showing area surveyed in Alabama.

CLIMATE.

From the official figures given below it will be seen that there is some difference in the normal temperatures and precipitation in the

two physiographic divisions of the area. The highest temperatures and least rainfall occur in the Cretaceous prairies to the north of Uniontown, while the lowest temperatures and greatest precipitation occur in the hill country, as shown in the records of Greensboro, Hale County.

The figures given are normals computed from records covering a period of ten years or more.

The rains are usually accompanied by east and southeast winds, while thundershowers usually approach from the west and southwest.

Normal monthly and annual temperature and precipitation.

Month.	Marion.		Uniontown.		Greensboro.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	Inches.	°F.	Inches.	°F.	Inches.
January	47.7	3.95	47.1	4.75	45.4	5.22
February	47.0	5.86	49.1	5.47	49.6	4.55
March	56.9	4.62	56.3	5.34	56.4	5.15
April	64.5	3.50	66.3	....	64.0	4.28
May	72.6	3.03	73.5	2.74	71.7	3.27
June	79.3	3.73	80.1	4.61	78.1	3.95
July	80.7	4.89	81.6	5.58	79.9	3.60
August	80.6	4.88	80.8	4.85	79.1	4.40
September	75.4	3.08	76.7	2.42	74.8	2.82
October	65.5	2.63	67.2	1.91	64.2	2.11
November	55.0	3.04	56.1	3.09	55.3	3.98
December	48.2	4.24	50.6	3.69	49.1	4.80
Year	64.4	47.45	65.4	....	63.7	48.13

The last killing frost of spring usually occurs about the middle of March and the first in fall in the first week of November. This gives a growing season of two hundred and thirty-seven days, approximately.

PHYSIOGRAPHY AND GEOLOGY.

Perry County comprises two main physiographic divisions. One is known as the uplands, the other as the prairie region. Between these divisions and distinctly separating the one from the other is the Eutaw escarpment.

The prairie region presents little variation of topography, being level, or nearly so. Only here and there is the monotony of the surface broken by low elevations—sand knolls of the Lafayette formation and the Lime Hills. The prairies cover the whole of the southern and southwestern parts of the area surveyed and gradually ascend the easy grade and moderate elevation of the Eutaw escarpment to the rolling, roughly rolling, and hilly country of the geological formation to the north.

Throughout the uplands occur long, narrow divides. The country

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is gently rolling along these divides, but between them the ravines are often deep and steep sided and along some of the streams even precipitous. In this part of the area the streams are constantly heading farther back into the hills and widening and deepening their channels.

The general slope of the surface and the drainage of the country is toward the south. Most of the smaller streams enter the Cahaba River within the county or in Dallas County to the south, while a few flow south into the Alabama River, and a few others, rising in the western part of the county, flow in a westerly direction and empty into the Black Warrior River. The Cahaba River flows through the county from north to south. Its course is tortuous and is bordered on one side or the other by broad bottoms and terraces. There are three of the latter, all well marked and giving rise to some of the important soil types of the area surveyed.

Perry County lies wholly within the Coastal Plain and is much more uniform geologically than the tide-water areas of the unconsolidated formations. The chief formations are the Tuscaloosa, Eutaw, Selma Chalk, and Lafayette. All belong to the Cretaceous period except the Lafayette, which is Post-Tertiary.

The Tuscaloosa consists of thick beds of joint clay and cross-bedded sand. The Eutaw overlaps the Tuscaloosa and is also a shallow-water deposit, consisting of cross-bedded sand and strata, varying in thickness, of laminated blue clays. The shell beds along the Eutaw escarpment, particularly east of Hamburg, are upper divisions of this deposit and mark a transition stage between the Eutaw formation and the Selma Chalk or Rotten Limestone.

The Selma Chalk, Rotten Limestone, or Prairie was the offshore deposit laid down in a rapidly deepening sea. This formation consists of beds of white limestone and gives rise to one of the important soil types of the area.

The Lafayette constitutes agriculturally the most important formation, giving rise to or modifying all the soils of the area. The origin of this formation, which is spread over the entire area of the Gulf States and consists of gravels, sands, and loam laid down over denuded areas of the Eutaw and Tuscaloosa formations, is somewhat doubtful. Whether the deposition took place during encroachment of the waters of the Gulf or while the country was covered by rapidly moving currents of water is not definitely known, but owing to the absence of marine fossils and judging from the structure of the deposits the latter theory seems the more plausible.

Following the deposition of the Lafayette formation the entire area was elevated and subjected to extremely severe erosion. So great was this that in many places the Lafayette was almost entirely removed—a condition existing, for example, in the prairie.

The most recent deposit is the Pleistocene, which forms a mantle of

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sand over much of the area. This occurred during a depression of the land surface, when the waters of the Gulf extended up the rivers and estuaries. This deposit forms the second bottom lands.

SOILS.

There are six types of soil in Perry County. These are shown in color on the map accompanying this report. The table below gives the area of each type and the proportion which each forms of the total area surveyed:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Orangeburg sandy loam	196,288	40.2	Sassafras sandy loam	14,720	3.0
Houston clay	136,128	28.0	Norfolk sand	4,160	.8
Orangeburg clay	82,752	17.0	Total	487,744	100.0
Meadow	53,696	11.0			

ORANGEBURG CLAY.

The most extensive areas of the Orangeburg clay occur between Oakmulgee Creek and Cahaba River north of Perryville, and isolated areas are found throughout the Orangeburg sandy loam. The soil is a gray or reddish-brown sandy loam or loam, having a depth of 8 inches, resting on a stiff red clay.

The type occupies rolling divides and rough, hilly country, where the sandy covering of the Orangeburg sandy loam can not accumulate to any considerable depth. These areas also indicate some of the largest settled districts and some of the first settlements of the area.

In general this soil, like all others found in Perry County, is used almost entirely for the production of cotton, although grain, vegetables, and fruit are reported to do well upon it. The Orangeburg clay produces from 800 to 1,500 pounds of seed cotton to the acre. The lint is of a little better quality than that produced on the Houston clay, but not so good as that grown on the more sandy types of soil.

The yield per acre of corn varies from 10 to 20 bushels. The corn is planted in hills 3 feet apart with rows 4 feet apart to allow of cultivation in both directions, which, owing to the occasional long and severe summer droughts, is considered necessary. Wheat and oats are successfully grown. The grain and straw are both used for hay, and very little of this is baled. The Orangeburg clay is the only soil in the area upon which wheat does not suffer from rust.

Of the fruits, grapes, peaches, and apples are grown to a limited extent for home consumption. The peach trees are short-lived, lasting only about five years. This is largely due to the methods used. The trees are seldom if ever pruned and are rarely cultivated. The

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fruit, however, is of good quality and splendid color. The Orangeburg clay is subjected to severe washing and is deficient in organic matter.

The following table gives mechanical analyses of soil and subsoil of this type:

Mechanical analyses of Orangeburg clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7893	1¼ miles E. of Felix.	Sandy loam, 0 to 5 inches.	0.89	1.96	15.60	21.38	32.42	9.64	14.42	4.58
7895	4 miles W. of Marion.	Sandy loam, 0 to 6 inches.	.92	.20	1.70	8.54	45.04	14.24	19.88	10.78
7897	1 mile N. of Chadwick.	Brown loam, 0 to 9 inches.	2.56	.74	4.90	10.20	27.46	12.70	22.50	22.14
7896	Subsoil of 7895....	Stiff red sandy clay, 6 to 36 inches.	.43	Tr.	.88	5.08	28.14	11.92	25.94	28.48
7894	Subsoil of 7893....	Heavy red clay, 5 to 36 inches.	.34	1.84	9.18	13.12	21.42	6.96	18.00	29.60
7898	Subsoil of 7897....	Red sandy clay, 9 to 36 inches.	.69	.50	3.50	8.16	19.70	8.68	25.52	34.06

ORANGEBURG SANDY LOAM.

The Orangeburg sandy loam has the largest distribution of any soil in the area surveyed, occurring to the north of the Eutaw escarpment and occupying the rolling country. The soil consists of a gray sandy loam, from 8 to 24 inches deep, resting upon a red or reddish-yellow clay, extending to a depth of 3 feet or more and of the same character as the subsoil of the Orangeburg clay.

The Orangeburg sandy loam is used for cotton production to the general exclusion of other products, except corn. The yield of cotton on this soil varies considerably, the average under fair conditions of season and cultivation being not far from a third of a bale to the acre. Corn will yield from 10 to 20 bushels to the acre, but wheat can not be grown successfully, on account of the rust.

A short-staple cotton is produced, although the product of this soil is superior to that of the Houston clay or Orangeburg clay and grades about three points above middling in the market. Small patches of cigar tobacco, for home use only, are grown on this soil.

The Orangeburg sandy loam is adapted to truck crops, of which sweet corn, sweet and Irish potatoes, cantaloupes, watermelons, asparagus, and peas of fine quality are produced. Of the fruits, Kieffer

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pears, peaches, and some varieties of grapes have a special adaptation to this soil.

The soil is not usually well protected by vegetation or position from the effects of the severe rains, and the areas are very generally washed. A great deal of the surface soil has been deported to the lower levels. Washing is most noticeable in the cleared areas where there is no protection of the slopes by terraces or sidehill ditches.

The following table shows the mechanical analyses of soil and subsoil of this type:

Mechanical analyses of Orangeburg sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7905	2 miles SE. of Perryville.	Sandy loam, 0 to 8 inches.	0.38	0.40	4.32	9.84	43.30	19.58	19.36	2.98
7903	4 miles NW. of Marion.	Sandy loam, 0 to 22 inches.	.70	.14	1.22	8.96	55.40	6.44	22.90	4.52
7899	2 miles E. of Brushcreek.	Sandy loam, 0 to 11 inches.	.54	.34	.70	3.06	55.52	22.80	11.00	6.44
7901	4 miles SE. of Brushcreek.	Sandy loam, 0 to 8 inches.	.67	.30	1.24	3.76	36.78	16.30	22.14	19.40
7904	Subsoil of 7903......	Stiff sandy clay, 22 to 36 inches.	.26	.02	.88	7.18	47.82	5.96	17.78	20.08
7906	Subsoil of 7905......	Red sandy clay, 8 to 36 inches.	.37	.24	2.56	5.62	25.74	11.44	27.66	26.10
7902	Subsoil of 7901......	Red sandy clay, 8 to 36 inches.	.58	.06	.70	2.98	30.30	10.72	25.38	29.26
7900	Subsoil of 7899......	Stiffred sandy loam, 11 to 36 inches.	.33	.00	.18	1.84	41.04	10.50	7.24	39.00

HOUSTON CLAY.

The Houston clay, commonly known as the "black belt" or "cane brake," constitutes nearly one-third of the area surveyed and lies south of the Eutaw escarpment. The soil is a brown, reddish-brown, black, or gray clay loam, from 4 to 8 inches deep, grading into a yellow or mottled clay subsoil of a stiff, plastic character and underlain at a depth varying from 1 to 3 feet by blue or gray joint clays.

This soil owes its origin to a Cretaceous sediment laid down in a rapidly deepening sea and known as the Rotten Limestone or Selma Chalk formation. This marine deposit was laid down in horizontal beds, and its nearly level surface extends for miles with monotonous uniformity, relieved only here and there by knolls of the Lafayette sands—remnants of a former mantle covering the whole area, or by the moderate elevations of the Lime Hills—areas of more resistant

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limestone. The soil cracks in the summer heat, but is very plastic when wet.

The Houston clay is used largely for cotton culture, but is not so well adapted to this crop as the Orangeburg clay. In a favorable season it produces from one-half bale to a bale per acre, but this yield can be counted on only about once in five years.

In times of drought this type is said to suffer much more than the sandy types.

The soil is admirably adapted to stock raising. Johnson grass yields an average of about 1½ tons of hay to the acre. This hay brings from $8 to $14 a ton. This grass, which is very nutritious, well withstands the severe droughts so common to the area.

Corn and oats do well. Corn yields from 25 to 30 bushels and oats from 25 to 40 bushels to the acre. Wheat rusts badly and is not much grown on that account. The legumes, including alfalfa, are well adapted to this soil. Alfalfa yields a ton to the acre at each cutting, and three cuttings are made during the season.

The Houston clay is very difficult to work. Experience has shown that the best practice is to break it up thoroughly in the fall when dry, using a two-horse turn plow or disk plow. It is then said to give a very good tilth when prepared for a crop the following spring.

The following table gives mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Houston clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7889	1½ miles SE. of Uniontown.	Clay loam, 0 to 5 inches.	1.04	2.44	2.72	1.12	2.30	19.42	51.94	20.06
7887	3 miles E. of Hamburg.	Clay loam, 0 to 8 inches.	1.35	.52	1.66	2.84	13.30	9.40	45.86	26.42
7891	6 miles NE. of Uniontown.	Clay loam, 0 to 6 inches.	.92	4.40	11.64	8.18	12.30	8.18	27.56	27.36
7888	Subsoil of 7887......	Mottled clay, 8 to 36 inches.	.74	.32	.76	.84	5.82	8.82	47.22	36.22
7892	Subsoil of 7891......	Stiff clay, 6 to 36 inches.	.70	.06	.28	.26	.96	9.64	36.82	51.68
7890	Subsoil of 7889......	Mottled clay, 5 to 36 inches.	.58	1.02	1.44	.46	.90	7.84	34.10	53.32

SASSAFRAS SANDY LOAM.

The Sassafras sandy loam occurs along the second bottoms of the Cahaba River and in parts of the bottoms bordering Oakmulgee

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Creek, at an elevation of about 20 feet above high-water mark. The soil is a gray or brown sandy loam from 8 to 24 inches in depth, grading into a sticky sand and resting upon a yellow or reddish-yellow sandy clay.

The surface of this soil is level or gently rolling, and the areas lie between the first bottom and the rolling country in narrow bands or, when the bayous and streams surround them, in detached patches. This soil owes its origin to the Pleistocene sands laid down during the encroachment of the Gulf waters at a period of subsidence of the land. The subsoil is derived from the sands reworked with the underlying gray clay.

The soil is very easy to work, but requires very careful management to maintain its fertility. It is well drained during the summer season, but wet and spongy in winter. The subsoil is compact and firm in the dry season, but loses its coherence when wet. The use of fertilizers is of only temporary benefit.

Cotton is the chief crop produced on the Sassafras sandy loam within Perry County. The yield per acre ranges from one-third to one-half bale. In favorable years the yield is considerably greater than this. Corn yields from 15 to 25 bushels per acre. However, this soil is much better adapted to truck crops than to any others.

The following table gives the mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Sassafras sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7909	Sprott	Sandy loam, 0 to 10 inches.	2.01	1.64	12.78	14.20	27.18	9.92	25.88	8.62
7907	4 miles S. of Sprott.	Sandy loam, 0 to 24 inches.	1.00	.12	1.22	6.54	54.24	15.02	18.34	4.38
7910	Subsoil of 7909	Yellow sandy clay, 10 to 36 inches.	.57	1.44	14.24	13.96	22.70	7.56	26.38	13.52
7908	Subsoil of 7907	Sandy clay, 24 to 36 inches.	.34	.04	.46	3.68	43.12	12.90	20.92	18.48

NORFOLK SAND.

Norfolk sand has only a very limited distribution in Perry County, occurring chiefly along Boguechitto Creek, west of Hamburg. The soil consists of a fine to coarse gray sand, from 1 to 3 feet deep, underlain by a sticky sand of the same texture, in turn resting upon the

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Houston clay. Where this type merges into the Houston clay the areas are characterized by a shallow deposit of sand.

The Norfolk sand owes its origin to the Lafayette sands, which at one time entirely covered the Houston clay. Subsequent erosion on a tremendous scale denuded nearly the whole of the area, leaving only traces of the Lafayette in the little knolls of sand scattered throughout the prairie along the margins of Boguechitto Creek. This area has all the characteristics of a delta.

The Norfolk sand produces cotton of better lint than any of the other soils in the county, but the rate of yield is very low, a bale to every 6 acres being considered a good average yield. Naturally this soil is best adapted for producing early truck, but the industry is as yet practically undeveloped.

The following table shows the texture of this soil:

Mechanical analysis of Norfolk sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7917	2¼ miles NE. of Newbern.	Fine loamy sand, 0 to 36 inches.	2.37	0.04	0.38	6.42	66.60	9.88	13.42	3.20

MEADOW.

The Meadow lands of this area consist of low-lying and poorly drained tracts, chiefly found along the Cahaba River, usually occupying the first and second terraces subject to overflow.

In favorable seasons this type, which consists of a waxy clay or clay loam, is the most productive cotton soil in the area, yielding with little or no fertilization from three-fourths to 1 bale per acre.

AGRICULTURAL METHODS.

In cultivating cotton the land is plowed in the winter or early spring and laid out in beds with a half-shovel plow. A diamond-scooter plow is next used to open up the center of the bed, and this is followed by a mechanical cotton planter which drops and covers the seed in one operation. When the plants are about ten days old the beds are barred off and the unnecessary plants are cut out with a hoe. The rest of the cultivation, which is frequent enough to keep down the weeds, is done with a sweep plow.

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There have been marked improvements made in recent years in the methods of ginning and handling cotton. Formerly the cotton was hauled to a horsepower gin, unloaded by hand into bins, and thence carried to a platform and fed into the gin by hand. The lint was blown into a lint room and allowed to accumulate until there was enough for about three bales, when it was conveyed by hand to the old "buzzard-wing" press, of which a few are to be seen at the present time. As the ginning progressed the seeds fell upon the floor and were shoveled through a chute to a pile outside the building, where they were allowed to rot. To-day a suction tube is used to elevate the cotton from the wagon. Through this the cotton is passed directly to the gin. The seed falls into a box, whence it is by belt elevators or blowers carried to storage bins. The lint passes into a condenser and from this to a steam-power press, where it is baled, tied, weighed, and made ready for shipment.

Some of the most improved gins have a "cleaner-feeder" attachment, which gives the cotton a more thorough cleaning. This effects a higher grading, and occasionally makes a difference of a cent a pound in the price received for the cotton.

The production of corn does not receive the attention it deserves, but still this product is one of the chief crops of the county. It is planted in 3-foot hills with 4-foot rows, which allows cultivation in both directions. The rate of yield is very low, but is in proportion to the seed sown and the natural productivity of the soils. Grass is confined almost entirely to the prairie section and is usually Johnson grass. It is cut with horse mowers and manipulated with horserakes. The partly cured grass is thrown up in small cocks overnight, spread out the following day, and if the weather is favorable it is then hauled to the barn or stacked in the field. Oats are grown, but mainly for forage. This crop is usually sown broadcast during the fall months.

Sugar cane is grown chiefly in the hilly country. The crop is grown from cuttings planted annually. The stalks from which cuttings are made are buried in the ground during the winter and dug out in the spring. At maturity the leaves are stripped from the stalks and the stalks cut and sent through a mill. The juice is evaporated and made into sirup, which brings from 20 to 50 cents a gallon. Sorghum is also grown largely, in both the hill and the prairie country.

AGRICULTURAL CONDITIONS.

The most prosperous part of the area, as indicated by the character of the farm buildings, is confined to the second bottoms of the Cahaba River. Next in development come the farms located in the Orangeburg clay, the Houston clay, and the Orangeburg sandy loam, in the order named. Existing conditions do not indicate that Perry County has enjoyed unbroken prosperity.

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Occasional comfortable old mansions are seen. These are usually built of wood, with large central halls extending from front to back. On each side of this hall open exceptionally large rooms, each provided with an ample fireplace. Few of these buildings are kept in good repair, while many of them are occupied by negroes, and their dilapidated appearance tells the story of broken fortunes.

Aside from these old mansions the greater number of the dwellings occupied by the whites are small one-story structures, sometimes clapboarded, but more often faced with logs and usually unpainted. There are large areas in which the log cabins of the negroes are the only dwellings to be seen.

The barns and outbuildings are generally small, but in proportion to the number of stock kept and the crops to be housed. Occasionally barb-wire fences are seen, but more often the stake-and-rail construction is made use of where any fencing at all is necessary. The greater part of the lands are without fences of any kind. The farming implements are generally inadequate, although there has been some improvement in this respect within the last few years.

In the part of the county below Marion and to the west of the Cahaba River, known as the prairies, not over one-third of the landowners live on and till their land. In the hill country probably three-fifths of the lands are occupied by the owners. The proprietors of the farms usually reside in Marion or Uniontown, the only important towns in the county. About one-third of the prairie is rented to white tenants, of whom probably three-fourths pay a stated cash rental, while the remainder work on shares. Under the latter method the tenant agrees to plant one-half or more of the tillable land of the farm and to give the owner from one-fifth to one-fourth of the cotton and cotton seed produced. Many owners lease, and often white or colored tenants sublet the lands to negroes at prices ranging from $1 to $3 an acre. Another common method of working the land, locally known as the "tenants-in-common system," is followed. By this system the owner or superintendent rents land to a "squad," consisting of negroes enough to work two or more mules. The usual allowance of land to each mule is 25 acres. Under this method the owner furnishes the land, implements, and seed, while the tenant furnishes the labor. Fertilizers are seldom used. The area to be put in each crop is stipulated in the agreement, and the tenant is entitled to one-half the cotton and cotton seed and one-third of the corn and fodder.

In Perry County the amount of land owned by the negroes is less than 5 per cent. The farms vary much in size. Of the total acreage, only about 5 per cent is included in farms containing from 80 to 160 acres, while 55 per cent is in plantations of 160 to 800 acres and 40 per cent in plantations of from 800 to 1,500 acres.

Land values are variable. The Houston clay is worth from $7 to

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$25 an acre, the Orangeburg sandy loam south of Marion from $3 to $25 and in the northern part of the area from $3 to $5 per acre. The Sassafras sandy loam brings from $7 to $15 and the Orangeburg clay from $3 to $10 an acre.

The planters depend entirely upon negro labor, of which 90 per cent is employed under some form of tenantry. The remaining 10 per cent is hired by the month, receiving from $7 to $10 a month with rations, or 40 cents a day without rations. Much of this labor is inefficient, but some of it is very satisfactory, and many planters believe it the only labor suited to the cultivation of cotton. As long as it is employed so generally no other kind of labor can be obtained, and the planters consider it fairly efficient where proper supervision can be had.

Alabama ranks third among the States in the production of cotton, with an annual output of about 1,000,000 bales. Of this great total, Perry County produces from 20,000 to 30,000 bales. Cotton is the one important staple of the county, and it is grown almost to the exclusion of any other crop. Corn and hay are the secondary products.

The grading of cotton is based upon the length and quality of the lint, the amount of trash it contains, and the color. In classification the cotton grown in this area will grade from straight middling to middling. The prices received by the planters have ranged anywhere from 5 to 8 cents a pound.

The Houston clay occupies the largest area, but is a very uncertain soil for cotton on account of its liability to drought. With a favorable season the soil returns large yields, but year in and year out the Orangeburg clay or the Orangeburg sandy loam produces more. Houston clay is adapted to oats, corn, and Johnson grass. Cattle are brought in from Tennessee and from the sandy uplands of the county and fattened upon pastures of this grass, and there is great opportunity for the development of this industry. The Johnson grass is one of the few grasses that can withstand the severe droughts of this section.

The Orangeburg sandy loam has been to a large extent exhausted, but it is a soil which responds readily to fertilization. It produces a much finer lint than either the Orangeburg clay or the Houston clay, but the rate of yield is very low. The soil is better adapted to corn, sweet and Irish potatoes, tomatoes, and other truck crops, stone and cane fruits, and wrapper tobacco.

The Orangeburg clay produces on an average the highest yield of cotton of any of the Perry County soils. It is admirably adapted to the general farm crops, including grass and grain, and to peaches and grapes. This soil is generally considered difficult to till, and consequently insufficient preparation of lands before planting and inefficient cultivation of the crops afterwards greatly lessen the yield.

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The Sassafras sandy loam of the second bottoms has a crop value somewhat similar to the Orangeburg sandy loam, with the exception that it will withstand drought better. It is very difficult, however, to keep up the fertility of this soil, owing to the character of the subsoil. It produces fair yields of cotton and corn.

The Meadow, or overflowed bottom land, in favorable seasons produces very heavy yields of cotton and corn. It is adapted to pasturage and the production of sugar cane and sorghum. The cane grown on the sandy bottoms is much better than that produced on the clay, making a superior quality of sirup. The presence of lime in the soil of the prairies is said to be detrimental to the growth of sugar cane.

Perry County offers unsurpassed possibilities for the development of agricultural industries. At present the local methods are of en crude and in most cases inefficient. There is need for greater care to prevent the washing of soils and to preserve their fertility. Deeper plowing is recommended, and more careful cultivation, especially on areas of Orangeburg clay and Houston clay. More perfect drainage systems would greatly improve the bottom soils, and contour cultivation and terracing should be more largely employed on the slopes.

The production of cotton year after year on the same fields, accentuated by the clean culture employed in the production of this crop, has more or less exhausted all the lands. The soils generally are deficient in organic matter, a condition which could be alleviated greatly by the use of green manures. Nearly all of the legumes do well upon the clay soils of the area, and especially on the Houston clay, while upon the more sandy types cowpeas and the California bur clover are successful soil renovators.

Many farmers would find it to their advantage to produce more of the subsistence crops, both for themselves and for the work stock, and to make cotton not the sole crop but the money crop. Large shipments of corn are now brought into the county. These and other imported agricultural products could and should be produced at home. The Houston clay and Orangeburg clay yield cotton of a longer staple than the other types of soil, and it seems that the long-staple cotton could be produced to advantage here. This cotton brings a considerably higher price than the cotton now grown in the area.

At the present time there are but one or two thrashing machines in the county, and wheat and oats are generally cut for hay. There are no flouring mills in the area, but nearly every gin has a gristmill for cracking corn and grinding corn meal.

At the present time the available markets for Perry County products do not warrant a more intensive agriculture, yet with the development of the mining section of the State to the north a greater demand for truck and fruit crops will eventually arise and a greater diversification of the industry will follow. The development of the

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trucking and fruit industries of the uplands and of the growing of grain and raising of stock in the prairies is only a question of time.

The transportation facilities are not what they should be. A branch of the Southern Railway, extending from Selma to Akron, passes through Marion, a town near the center of the county. A more important line passes through Uniontown, situated in the panhandle of the southern extremity of the county. The service is poor and freight rates high. In fact, the latter are a serious handicap on the development of agriculture and other industries in the county.

The wagon roads in the prairie section of the area are excellent when dry, but in the wet season they become practically impassable, as is evidenced by the fact that a pair of good mules is required to haul a single buggy. Consequently but little traveling is done, and that on horseback. The roads in the other parts of the county are very poor. Many districts are settled so sparsely that only enough repairing is done to keep the roads passable. The streams are subject to very sudden rises; only the larger ones are bridged, and fording of many of them is often impossible for a day or more following heavy rains. Under these conditions a 500-pound bale of cotton is considered a heavy load for a pair of mules.

Marion is the only market for the central part of the county. While Uniontown, in the southern extremity of the county, is a good market for cotton, it is too remote to serve as a point of shipment for cotton grown in the northern part of the area. Greensboro, a few miles west of the county line, in Hale County, is the market town of the northwestern part of the county. The eastern and southeastern sections depend largely upon Selma, although this town is situated 12 miles distant in Dallas County.

These three towns have cotton-seed oil mills, while Uniontown also possesses a cotton compress.

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SOIL SURVEY OF THE SMEDES AREA, MISSISSIPPI.

By **WILLIAM G. SMITH** and **WILLIAM T. CARTER, Jr.**

LOCATION AND BOUNDARIES OF THE AREA.

The Smedes area extends east and west 52 miles and is 18 miles wide north and south in the western half, while the remaining eastern part is only 6 miles wide. For convenience the area has been divided into the Smedes sheet and the Bentonia sheet. It adjoins on the south the area surveyed in 1901. The southern boundary is a straight east-and-west township line extending from the Choctaw meridian westward to the Mississippi River. The area lies in Ts. 9, 10, and a part of 11, north of the Choctaw base, and Rs. 1 to 9 W., inclusive. Parts of Yazoo, Madison, Issaquena, and Sharkey counties are comprised within the area. (See fig. 8.)

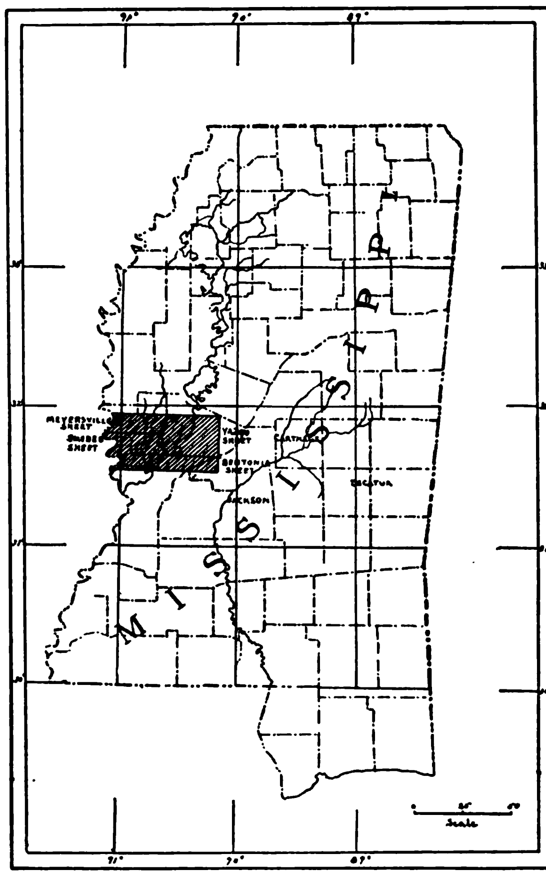

FIG. 8.—Sketch map showing areas surveyed in Mississippi.

There were no available road maps suited to the needs of the survey. The base used was made by plane-table traversing carried on in conjunction with the soil mapping. In making up the final base county maps were relied on to some extent.

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HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The region in which the Smedes area lies was first visited by Ponce de Leon, Pamfilo de Narvaez, and De Soto in the first half of the sixteenth century. These Spanish explorers, influenced by the treasure taken in the conquest of Mexico, explored this country, not with a view to developing it agriculturally, but in search of gold and other precious minerals and gems. Their failure to make permanent settlements, indeed, gave ground for the establishment of French sovereignty in the latter half of the same century, following the explorations of Father Marquette and Sieur de la Salle. The French in turn did little to advance the region agriculturally, although they built some forts, the most important being Fort Rosalie on the present site of Natchez, and Fort St. Peter, not far from the mouth of the Yazoo River, and held the country for nearly one hundred years. They were chiefly concerned in Christianizing the Indians and in fur trading. In these undertakings they suffered much from the warlike character of the natives.

The territory came under English rule by treaty with France in 1763, and under the policy of the English the real beginning of agriculture took place. The liberal offers of land by the Crown attracted men of character and ability to the new possession, the Indians were soon subjugated, and the laws of England, insuring security to life and property, were put in force.

Under such conditions it is but natural that agriculture made marked progress. Important settlements were made on the Bayou Pierre, the Big Black River, and the Walnut Hills. The most of these were on the uplands, but later some large plantations were opened up on the higher alluvial lands fronting on the main streams. Tobacco and indigo, once the leading staple crops, were in time supplanted by cotton. The old records also enumerate rice, sugar, flaxseed, corn, buckwheat, barley, pease, oats, rye, wheat, and potatoes as crops grown.

The laborers during this period seem to have been chiefly German redemptioners and African slaves. Iron was scarce, and wooden implements formed an important part of the farm equipment. The one principal means of transportation was by flatboat down the river to New Orleans, whence the products were shipped by trading vessels to the mother country and Europe. By the same means dairy products and other needed supplies were brought into the region from Ohio and other Northern territory.

The country took no part in the Revolutionary war, but rather served as a refuge for both parties to that struggle. It continued to grow and prosper, disturbed only occasionally by marauding bands from the contending armies at the North. But this agricultural progress was to receive another check. Galvez, the Spanish governor of

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Louisiana, in 1781 brought the territory by force again under Spanish dominion, following which change of sovereignty various circumstances tended to deaden industry.

The invention of the cotton gin, by Whitney, in 1794, however, gave a great impetus to cotton production in spite of the unfavorable political conditions. Yet the permanent well-being of the section was not assured until 1798, when it came under the authority of the Federal Constitution as a Territory.

Mississippi was admitted as a State in 1817. From that time to the present day cotton has remained the great staple crop of the area surveyed, and its prosperity has fluctuated with the price of this commodity. The almost exclusive cultivation of this crop has produced a system of agriculture far from perfect, a system calculated to impoverish the soil and to make the solvency of the tiller of the soil entirely too dependent upon the yield and price of this one crop. It has resulted in a system of liens against the growing crop, taken to raise the money to pay for necessaries of life that might be largely produced upon the farm.

This is unfortunate, but at the same time it brings distinctly to view the fact that the country has great possibilities before it in the introduction of a diversified agriculture, combined with rational treatment of its naturally fertile soils.

CLIMATE.

The climate of the region is that of the warm temperate zone of the United States. This would seem to admit of a wide diversification of crops, so that nearly all the chief agricultural necessities of the community should be produced within the area.

The temperature tables show a comparatively uniform range for both summer and winter. A fairly high temperature, with a high humidity, may, however, occur during July and August, when the heat becomes quite oppressive. The winters are quite open, the soil seldom freezing, and the housing of cattle being usually regarded as unnecessary. Occasionally the soil freezes an inch or two, and thin ice forms in the creeks, but such conditions rarely last more than a few days. Snow seldom falls, and when it does it remains on the ground but a short time. Still, occasionally much suffering has been caused by cold waves of unusual severity.

The first killing frost in the fall may be looked for about the first week in November, while danger from late spring frosts is past by the last week in March.

The annual precipitation for the delta area is thought to be somewhat higher than for the upland. The rains come mostly during the spring, fall, and winter months, while during the important cotton-picking season—September, October, and November—the precipitation is least.

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There were no weather-observation records obtainable for the area itself, but those included in the following table, from Weather Bureau records, are believed to represent the climatic conditions of the area fairly well:

Normal monthly and annual temperature and precipitation.

Month.	Agricultural College.		Greenville.		Vicksburg.		Yazoo City.		Crystalsprings.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	In.	°F.	In.	°F.	In.	°F.	In.	°F.	In.
January	....	....	45.7	5.38	47.6	5.76	46.4	6.06	47.7	6.52
February	....	....	48.1	4.36	52.2	4.70	45.4	4.43	48.9	5.19
March	....	....	52.4	5.84	58.2	6.14	60.0	5.69	59.2	3.97
April	64.8	3.21	66.5	4.14	66.0	5.86	66.8	4.48	66.8	3.69
May	71.8	3.26	72.9	3.45	72.6	4.94	76.3	3.02	74.1	3.65
June	78.2	3.39	78.9	3.72	80.0	4.67	81.4	3.96	79.8	4.73
July	80.9	5.32	81.4	4.33	81.2	4.47	83.4	4.92	81.4	6.74
August	79.9	4.47	80.6	3.80	81.2	3.32	83.5	4.71	80.8	4.42
September	73.5	2.74	74.6	2.86	76.0	3.37	76.9	2.42	75.9	2.53
October	64.6	1.62	63.1	1.95	66.4	2.69	64.5	1.80	66.8	2.08
November	54.0	2.86	53.5	3.74	56.2	4.48	55.5	3.10	56.1	3.19
December	48.2	4.17	47.7	3.77	50.6	4.96	47.7	4.09	48.8	5.64
Annual	....	....	63.8	47.12	65.7	54.42	65.6	48.68	65.5	53.11

Dates of killing frosts.

Year.	Agricultural College.		Greenville.		Vicksburg.		Yazoo City.		Crystalsprings.	
	Last in spring.	First in fall.	Last in spring.	First in fall.	Last in spring.	First in fall.	Last in spring.	First in fall.	Last in spring.	First in fall.
1892	Mar. 20	Nov. 11	Mar. 19	Nov. 11	Mar. 2	Nov. 11	....	....	....	Nov. 10
1893	Mar. 6	Oct. 29	Mar. 5	Oct. 16	Apr. 22	Nov. 15	....	Oct. 30	Mar. 30	Oct. 15
1894	Mar. 29	Nov. 9	Mar. 30	Oct. 31	Mar. 29	Nov. 11	Mar. 30	Nov. 6	Mar. 30	Oct. 9
1895	Mar. 21	Nov. 2	Mar. 21	Oct. 10	Mar. 17	Nov. 11	Mar. 21	Nov. 2	Mar. 21	Oct. 21
1896	Apr. 3	Dec. 3	Mar. 20	Oct. 18	Mar. 20	Nov. 9	Mar. 21	Nov. 8	Apr. 3	Nov. 6
1897	Feb. 27	Nov. 17	Feb. 27	Nov. 17	Feb. 27	Nov. 17	Feb. 27	Nov. 10	Feb. 27	Nov. 17
1899	Mar. 29	Nov. 3	Mar. 29	Nov. 3	Mar. 7	Nov. 3	Mar. 29	Nov. 3	Mar. 29	Nov. 8
1900	Apr. 5	Nov. 9	Mar. 17	Nov. 9	....	....	Mar. 31	Nov. 10	Apr. 1	Nov. 4

PHYSIOGRAPHY AND GEOLOGY.

The Smedes area consists of two distinct physiographic divisions—the Mississippi River flood plain or "delta," lying about 100 feet above the level of the Gulf of Mexico, and the upland or "hill country," lying about 250 feet above the delta lands. The delta extends from the Mississippi River to the upland, a distance of about 30 miles, with a relatively flat surface, whose variation in level is probably not more than 20 feet. The higher elevations of the delta occur next to the rivers and streams, and were therefore the first to be settled and tilled, and, indeed, the present cultivated areas are limited largely to these frontage lands. The drainage system consists of numerous steep-sided, winding streams, crooked bayous, and narrow lakes. These

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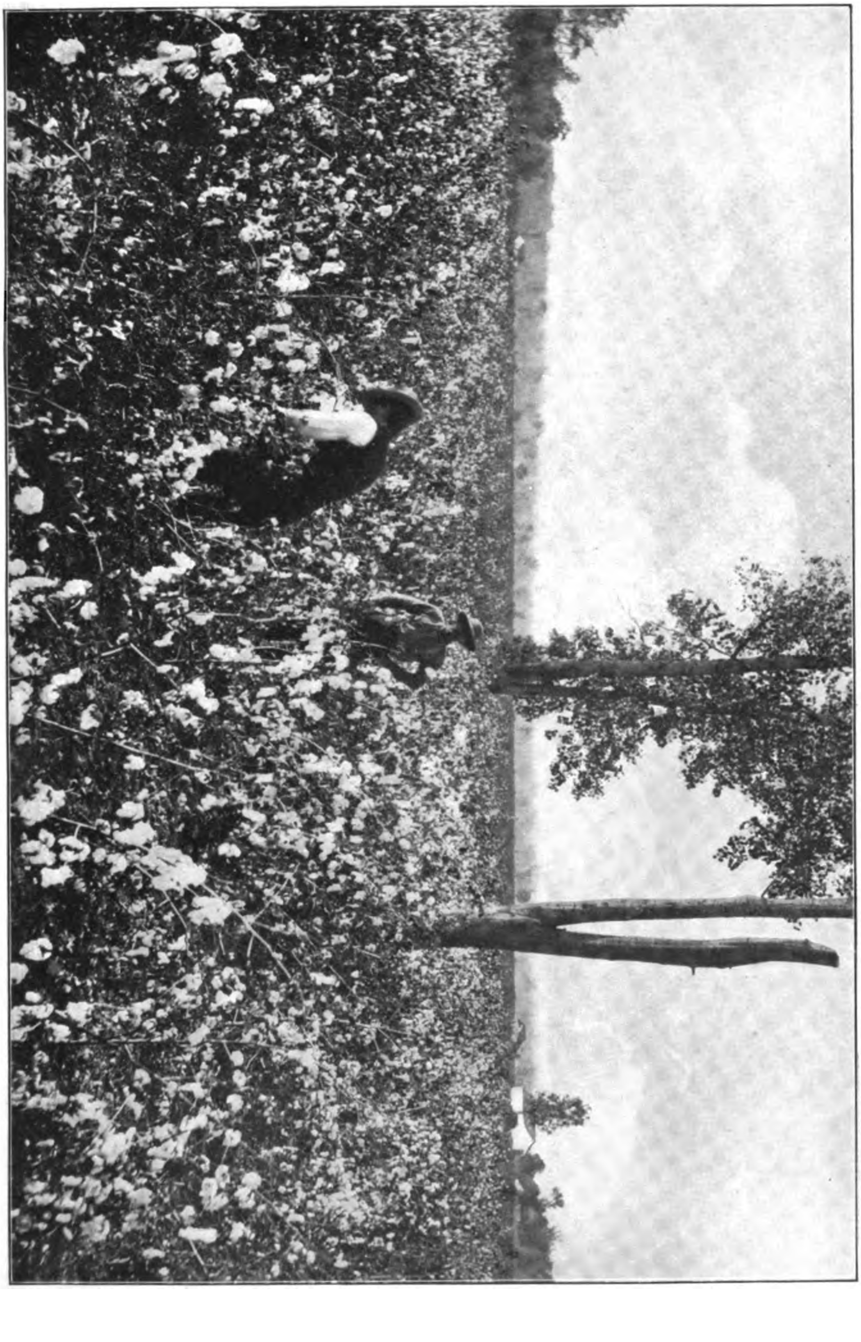

TYPICAL COTTON FIELD ON THE YAZOO LOAM, SMEDES AREA, MISSISSIPPI.

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during the wet season are usually full to overflowing. At other seasons they are quite shallow, or in many cases entirely dry.

The upland is separated from the delta or "valley land," as it is called locally, by a sharp escarpment about 150 to 300 feet high. This escarpment extends from Memphis to Baton Rouge as a long, flat arc. About one-sixth of the area of the State lies in the Mississippi River flood plain, while the remaining five-sixths consists of upland.

The upland comprised within the limits of the present survey extends from the delta lands to beyond the Big Black River, a distance of about 20 miles. Originally the surface was plateaulike, but it is now in places very much dissected. The upland itself, by reason of the difference in erosion, falls naturally into two distinct areas, known as the "Cane Hills" and the "Flat Hills." The area of the Cane Hills extends back from the delta lands about 6 miles. All the rest of the area consists of the Flat Hills. A line is drawn on the soil map, indicating approximately the boundary between these two sections.

The Cane Hills area consists of narrow, steep-sided ridges and cross ridges, flanked by deep, V-shaped gullies and stream valleys. The roads usually follow the main ridges, and when it is understood that the streams are usually from 20 to 100 feet lower than the crest of the ridges, some idea of the surface conditions may be gained from an inspection of the soil map. Only about one-fifth of the Cane Hills area, consisting of the tops of the ridges and some of the narrow stream bottoms, can be cultivated. The rest of the Cane Hills supports a natural hard-wood forest, and an undergrowth of switch cane and shrubbery, well suited for stock range. The streams of the section have quite a rapid fall toward the delta, and are subject to torrential floods.

In the Flat Hills area erosion has not been so great, the depth of the stream valleys ranging from 5 to 50 feet. The drainage is toward the Big Black River, and the fall is more moderate. Perhaps two-fifths or more of the surface of the Flat Hills section is now cultivated, while considerable more admits of cultivation.

The geological differences between the delta and the upland are fully as marked as the surface differences. The upland consists of an upper stratum of fine yellow silt (loess) 20 to 40 feet deep, underlain by a stratum of sand and gravel (Orange sand) 1 to 3 feet thick. This is in turn underlain by massive blue or yellowish-blue clay (Eocene), the thickness of which was not learned. The upper stratum is the one of greatest economic importance. The upland soils are derived solely and the delta soils in part from this material. The loess is marked by a very uniform silty texture throughout. It contains shells of the genus Helix, which have in part been dissolved by the action of ground waters. The lime thus derived has been formed in some instances into curiously shaped concretions and nodules. This loess is of wide distribution in the Mississippi Valley, extending from Iowa almost to the Gulf of Mexico. The sand and gravel stratum underlying the loess

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has very little effect on the soils, occurring at too great a depth to have much influence on the drainage. In deep road cuts it is exposed, and is thus available for surfacing the roads. Usually the sand and gravel is deeply stained, evidently by a brown or reddish-brown iron oxide. Frequently this stratum is found firmly cemented together.

The massive clay underlying the sand and gravel is very plastic and slippery when wet, and becomes very hard when dry. The line of demarcation between the clay and the superimposed stratum is quite distinct. The clay is very impervious to water, and where it outcrops along the bluff the ground is oozy, and there is much seepage water from the uplands. This clay stratum, however, generally passes beneath the delta.

Numerous marine shells, together with the vertebræ of sharks and whales, are found in the clay. Individual crystals of honey-colored gypsum are also found in outcrops, and here and there beds of lignite.

The geology of the delta area is even more simple than the upland. It consists of alluvial material laid down by the waters of the Mississippi and Yazoo rivers and their tributaries, in a valley previously excavated by the Mississippi River through the older geological formations. Geologically the delta is the youngest formation in the area, and it is still being formed by the addition of new material during inundations. Four important soil types are derived from this alluvium—a sandy loam, a loam, a friable clay, and a heavy, waxy clay. All are naturally fertile and each has undeveloped agricultural possibilities.

SOILS.

There are seven soil types in the Smedes area. Four of these types, the Yazoo sandy loam, Yazoo loam, Yazoo clay, and Sharkey clay, are derived from the alluvium of the Mississippi flood plain. The remaining three types, the Memphis silt loam, Lintonia loam, and Meadow, are found in the upland and are derived from the loess.

The following table gives the area of the different types, the total area surveyed, and the proportion which each type is of the whole:

Areas of different soils.

Soil.	Bentonia sheet.	Smedes sheet.	Total area.	Proportional extent.
	Acres.	*Acres.*	*Acres.*	*Per cent.*
Sharkey clay	7,488	141,952	149,440	50.5
Memphis silt loam	52,160	128	52,288	17.8
Yazoo clay	704	37,056	37,760	12.8
Yazoo loam	3,712	16,576	20,288	6.8
Meadow	17,408	....	17,408	5.8
Lintonia loam	9,280	1,088	10,368	3.5
Yazoo sandy loam	384	8,128	8,512	2.8
Total	91,136	204,928	296,064	....

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YAZOO SANDY LOAM.

The Yazoo sandy loam consists of 6 to 8 inches of medium to fine sandy loam varying from yellow to dark brown in color, underlain by a subsoil of brown loam, usually heavier in texture than the soil. The heaviness of both soil and subsoil varies somewhat. Where the type occurs along the Mississippi River where there has been a break in the levee, or where from any cause there has been a rapid flow of water, the texture is coarser; while farther inland, as, for example, along Deer and other creeks, the soil is quite uniformly a fine sandy loam underlain by a heavy subsoil sometimes quite clayey in texture. This is the texture, also, of much of the type as it occurs next to the Mississippi River, where it has been normally laid down, or, in other words, where it has been only indirectly influenced by breaks in the levees.

The Yazoo sandy loam occurs in narrow bands or ridges along the rivers, streams, and drainage ways. The surface is usually from 1 to 6 or more feet higher than the land lying more remote from the streams. The type may occur as a uniform band or slightly rounded ridge along a given stream, as knolls, or as a series of parallel ridges separated by narrow areas of clay or heavy loam. The latter areas are found in the bends of streams where the flood waters cut across. Such ridges are also found where breaks in the levees have occurred. The usual position of this soil type seems to be on the front lands of the streams, where it extends in narrow bands slightly elevated above the other soils.

Owing to its texture and also to its location the Yazoo sandy loam is naturally well drained. Its elevation above the other soils allows the surface water to flow off in all directions, while its open texture provides for a ready downward movement of the soil water.

The Yazoo sandy loam, in common with the other types occurring in the Mississippi River flood plain, owes its origin to deposition. The coarser materials held by the water naturally are the first to be deposited when the movement of the water is in any way checked. Thus as the streams become swollen and begin to overflow their banks a large part of the coarser material is almost at once deposited next the stream channel, while the finer silt and clay is carried farther inland to be deposited in thin layers by the stiller waters. The successive inundations of this character soon build up higher ground along the stream banks, generally of a sandy or light loamy texture. This material consists of fine particles of quartz and mica, with some admixture of silt and clay. These represent minerals that have, through weathering and the leaching action of water, been reduced to a relative chemical simplicity. Much of this soil type, however, contains some decayed vegetable matter, derived in part from the growth and decay of plant life on it and in part from that carried in by floods. The type is as a

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whole well supplied with plant food. The occasional flooding of the land doubtless accounts for the maintenance of its fertility. Most of the Yazoo sandy loam within the limits of the present survey has been under cultivation for over half a century, and some has been in use for more than three-quarters of a century. During all this time cotton has been grown almost exclusively. The yield of cotton ranges from one-half bale to three-fourths bale per acre, and in some cases yields of 1 bale or more are secured, especially when improved methods of tilling the land are practiced.

Corn is grown to some extent, but the rate of yield is low, being from 10 to 25 bushels per acre. Crab-grass hay and cowpeas are grown and fair yields are secured. Truck crops, such as sweet potatoes, Irish potatoes, cabbages, radishes, turnips, melons, etc., are successfully grown in a small way for home supply.

As has been said, cotton is the chief crop grown on the Yazoo sandy loam, and under the circumstances fair yields are obtained, but judging from its texture and location it would seem that this soil is better adapted to truck growing. This impression was strengthened by observation of the small patches of sweet potatoes and other truck crops grown around the plantation houses and negro cabins. These truck patches all gave evidence of good yields, even with the ordinary cultural methods in use. The location of this soil next the streams affords, in many instances, a ready means of marketing, while in some cases railroad transportation is available.

The Yazoo sandy loam is easily cultivated and has a market value quite as high as any of the alluvial soils, the price ranging from $20 to $60 per acre. The type is almost all cleared and under some form of cultivation. It is one of the best soils of the alluvial section.

The following table of mechanical analyses shows the texture of the soil and subsoil of this soil type:

Mechanical analyses of Yazoo sandy loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7992	¼ mile E. of Fitler P.O.	Loose sandy loam, 0 to 12 inches.	1.28	0.00	0.00	0.10	1.30	56.54	37.64	4.44
7994	1 mile N. of Smedes.	Brown sandy loam, 0 to 10 inches.	.92	.00	.20	.10	.44	16.80	72.74	9.70
7993	Subsoil of 7992......	Sandy loam to clay, 12 to 36 inches.	1.17	.00	.10	.08	.74	28.30	61.72	9.12
7995	Subsoil of 7994......	Sandy loam to loam, 10 to 36 inches.	.84	.00	.24	.24	1.50	3.60	60.56	33.76

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YAZOO LOAM.

The Yazoo loam consists of a dark-brown or yellow silty loam from 6 to 8 inches deep, underlain by a heavy drab clay subsoil containing considerable silt. The surface soil is loose and powdery when dry, and only moderately sticky when very wet. When normally moist it is very mellow and easy to cultivate.

The Yazoo loam is found as narrow bands along streams, lakes, bayous, and drainage ways. Being intermediate in texture between the Yazoo sandy loam previously described and the clay soils of the back lands, its location is naturally between areas of these types.

The surface of the Yazoo loam often has a gentle slope from the stream toward the back lands. Occasionally quite extensive areas show a flat or gently rolling surface.

The drainage of the Yazoo loam is similar to that of the Yazoo sandy loam, although it is not so complete. By reason of its location this soil receives the drainage from the Yazoo sandy loam, and its surface being rather flat the movement of soil water toward the back lands is not so rapid. However, by the aid of open ditches this type may readily be well drained when the streams are not abnormally high.

The Yazoo loam owes its origin to the same processes as the other delta soils. The particles of which it is formed are smaller than those of the Yazoo sandy loam and were laid down farther from the stream channels and in stiller water. The yet finer particles of clay in suspension in the flood waters were largely carried farther inland and slowly deposited or left by evaporation, resulting in the formation of the two clay types described later. The occasional extensive, flat areas of Yazoo loam near the foothills of the bluff may have been formed by the spreading of silt from the bluff land out over the delta clays during earlier periods of exceptionally high water. At any rate there is a very close similarity in texture between the soil of the Yazoo loam and that of the brown silty loam (Memphis silt loam) found on the bluffs.

The Yazoo loam, being heavier in texture than the adjoining sandy loam, may be regarded as containing minerals less reduced toward chemical simplicity, and therefore as containing a greater proportion of stored plant food. The dark color usually characterizing the soil would indicate the presence of a fair amount of decayed vegetable matter. At any rate, field experience indicates this to be a fertile soil, and the occasional overflows do much to maintain this natural fertility.

The Yazoo loam, like the type previously described, was one of the soils early cleared and used in the growing of cotton. Good yields of cotton are secured nearly every year, the yield per acre varying from three-fourths bale to 1 bale. (See Pl. XVI.) It is capable of growing good crops of corn, yielding from 20 to 40 bushels per acre, while the introduction of the methods employed in typical corn areas would no

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doubt greatly increase these yields. A change in present methods is certainly a matter worthy of serious consideration by the planters.

In adaptation this soil is very similar to the Yazoo sandy loam, and what was said relative to this subject in the description of that soil might be repeated with equal force here. A slow development of the truck interests might be brought about at this time.

The Yazoo loam is held at from $20 to $60 an acre. The average price is as high if not higher than any of the other soils in the area. Along the larger waterways the greater part of the type is cleared and under cultivation, but along the smaller streams and drainage ways located in the back lands, or "swamp" areas, much of the type still retains its original forest growth, consisting of oak, hackberry, gum, and other trees and shrubs. The undergrowth in these forests is almost always a thick stand of blue cane. This blue cane is seen in some of the abandoned fields. Unless great care is exercised crab grass takes possession of the cotton and corn fields. The coco grass also gives serious trouble and seems almost impossible to eradicate when once it gains a foothold.

This type, like the preceding, is used for building sites. The improvements consist usually of the plantation house of the owner or manager, valued at from $800 to $2,000; a barn and sheds, valued at from $100 to $1,000, and, somewhat removed from these, several negro cabins, valued at from $50 to $100 each.

On the whole, the Yazoo loam is one of the choice soils of the area. It was much sought after by the early settlers and is still in demand. Its texture and location are features that make it particularly desirable.

The following analyses show the texture of the soil and subsoil of this type:

Mechanical analyses of Yazoo loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7990	¼ mile W. of Smedes.	Brown, slightly sandy loam, 0 to 10 inches.	1.23	0.00	0.18	0.14	0.74	16.42	65.58	17.00
7991	Subsoil of 7990......	Brown loam, 10 to 36 inches.	.91	.00	.12	.20	1.50	13.68	60.04	24.32

YAZOO CLAY.

The Yazoo clay consists of a drab or bluish clay soil about 5 inches deep, underlain by a plastic mottled yellow or grayish clay. Sometimes a layer of sand is encountered at a depth of 3 or 4 feet. The

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type is locally termed "buckshot" land. This term has reference to the peculiar manner in which the clay breaks up, upon drying, into small cubical aggregations about the size of buckshot. This term is also used for certain of the soils occurring in the bluff land, but here the soil is silty in texture and contains numerous dark-brown iron concretions about the size of buckshot. There is no marked similarity between the delta soil and the bluff soil.

To the farmers there are two classes of Yazoo clay, known as "blue buckshot" and "black buckshot" land. These terms characterize in a general way the amount of vegetable mold in the clay, and to the tiller of the soil it means the one is difficult to plow and cultivate, except within certain very narrow moisture limits, while the other admits of plowing and tilling under quite a wide range of moisture conditions. The blue buckshot if plowed when too wet sinks back into the furrow and the field dries off, leaving a surface hard and refractory, while if plowed when too dry large clods, very slow to disintegrate, are turned up. On the other hand, the black buckshot, except when very wet or very dry, mellows down into excellent tilth after plowing. After a few years of cultivation and the addition of vegetable matter the two phases become about the same.

The Yazoo clay, when undisturbed by tillage, upon drying is dissected by a system of cracks, often several inches in depth. The surface wash of fine dark clay and organic matter fills these cracks, and much fertility is thus incorporated with the soil. This process materially assists the work of cultivation by improving the tilth.

The Yazoo clay occupies the low-lying border of the frontage lands of the streams. It represents the third grade of alluvial soil in point of texture, as well as in location, beginning with the sandy and loamy soils found on the front lands.

The surface of the Yazoo clay is generally quite flat, and this in connection with the clayey texture results in imperfect drainage. It is necessary to assist the natural drainage by open ditches. For much of the type these still need to be extended. This open-ditch method seems to be best suited to the type. The conditions are such at present as would probably not warrant the expense of drainage with tile. Owing to the compact nature of the subsoil tile drains would have to be placed at quite frequent intervals to be effective. As the population increases and these lands become more in demand, and as a more intensive system of tillage is instituted, a combination of the open-ditch drain and tile drain systems will doubtless find a place on the Yazoo clay, just as it has in the areas of heavy clay soils in Ohio.

The Yazoo clay owes its origin to deposition in comparatively still water. It is formed of the clay and fine silt particles which were longer in suspension than the heavier particles of the front land soils.

This soil is naturally very fertile. The heavy texture and the

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countless numbers of particles of clay and fine silt afford abundant opportunities for the absorption of soluble salts from flood waters. Judging from the crops secured under the exhaustive system of cropping practiced, it would seem as if the adsorption theory of soluble salts for use as plant food finds here a practical affirmation. Chemical analyses of soils in Louisiana similar to this type have revealed a lime content as high as 1 per cent. This comparatively large amount of lime in the soil, together with the high content of organic matter, probably accounts in a large measure for the peculiar manner in which this clay breaks up into small cubical aggregations. The water drawn from wells sunk in the Yazoo clay has a very disagreeable taste. When first drawn it is quite clear, but after standing a few hours it turns a yellowish-green color, due possibly to an alteration of the iron salts in solution. Rain water is relied on almost entirely for drinking purposes.

Cotton is the chief crop on the Yazoo clay. Occasionally some corn is grown. The yield per acre of cotton averages about 1 bale; of corn, from 20 to 40 bushels. Good yields of crab grass, Bermuda grass, and cowpeas are secured.

The Yazoo clay is a fertile, productive soil, well suited to the growing of cotton. It may be regarded as the typical cotton soil of the area. Where extra care has been practiced yields closely approximating 2 bales of cotton to the acre have been obtained. It also produces corn and grass well. It would seem as if turnips, onions, and other garden crops requiring a heavy soil might be grown successfully.

The Yazoo clay is held at prices ranging between $20 and $60 an acre. It is much in demand, is highly prized by those who own it, and little if any of it is on the market.

A great part of the Yazoo clay is cleared and under cultivation, and the cultivated area is gradually being extended by clearing up some of the more remote "back lands." Much of the type has been many years under cultivation, and yet it shows little sign of being run down, even with the exhaustive methods practiced by the planters up to the present time, for it is now one of the most productive soils of the delta region, with possibilities of further improvement that will make it a great deal more productive and valuable.

The table of mechanical analyses on page 337 shows the texture of the soil and subsoil of the Yazoo clay.

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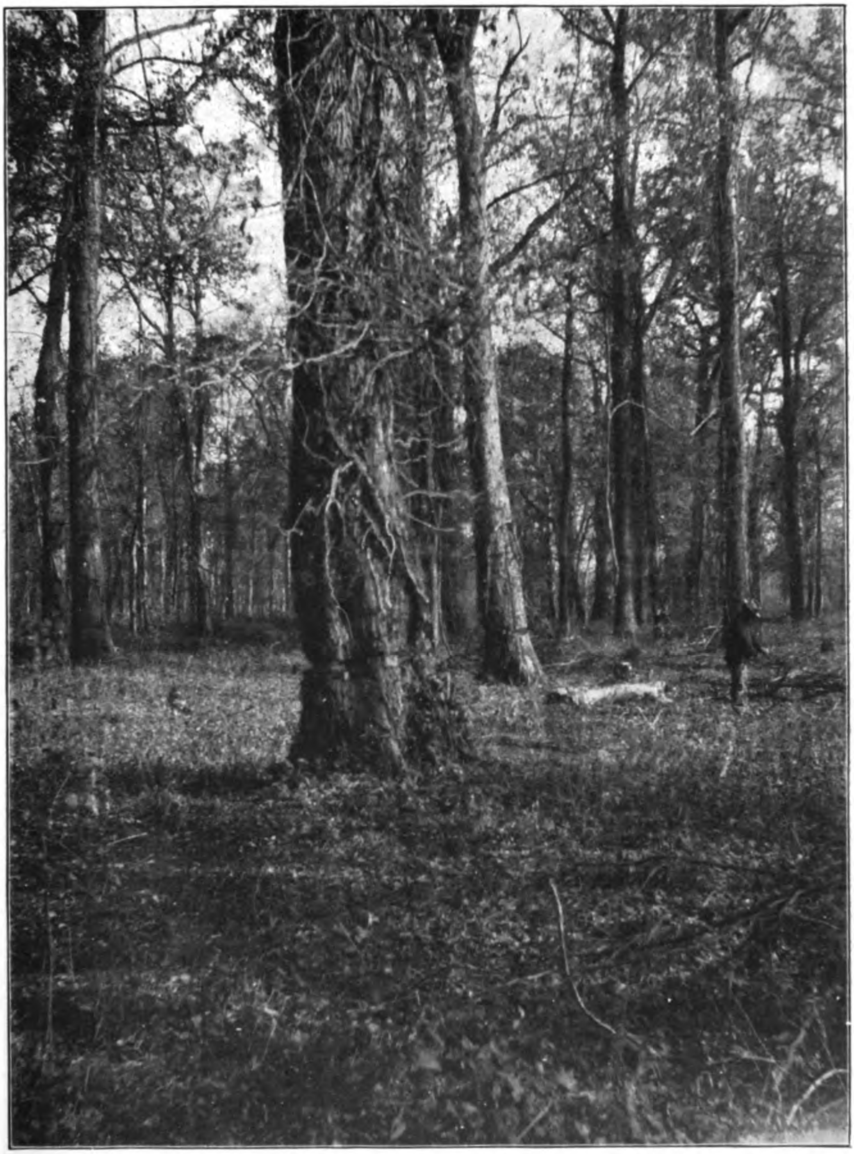

CHARACTERISTIC HARD-WOOD FOREST GROWTH OF THE SHARKEY CLAY, SMEDES AREA, MISSISSIPPI.

This soil is annually under water from the river floods until the first of June, after which it is too late to plant and mature crops. It is exceedingly fertile and could be reclaimed by dikes.

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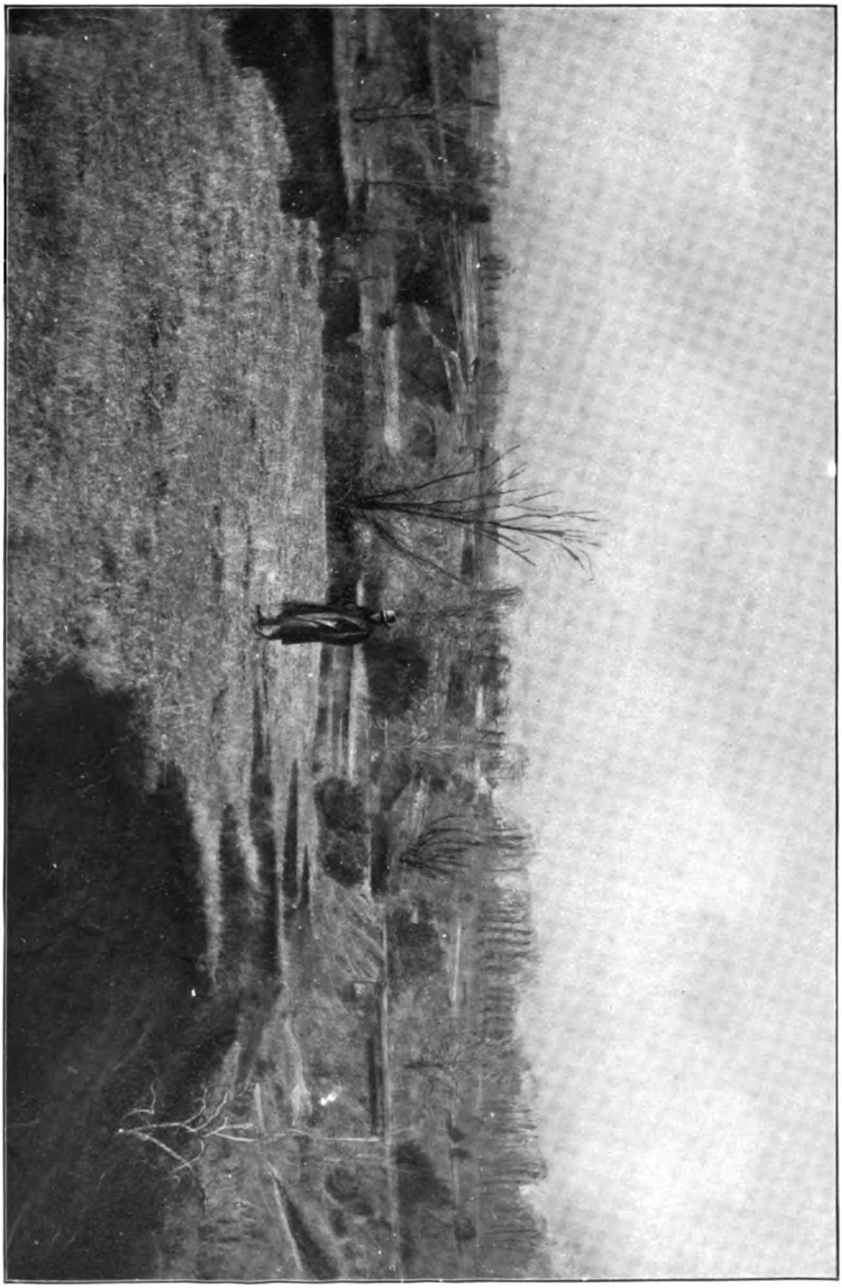

A TYPICAL SCENE IN THE CANE HILLS REGION OF THE MEMPHIS SILT LOAM, SMEDES AREA, MISSISSIPPI.

The soil is everywhere eroded and cut up in the most frightful manner.

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Mechanical analyses of Yazoo clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7988	1/8 mile E. of Smedes.	Dark clay, 0 to 6 inches.	1.33	0.10	0.20	0.14	0.50	4.04	48.00	46.98
7989	Subsoil of 7988......	Dark clay loam to clay, 6 to 36 inches.	.90	.00	.20	.24	1.64	7.52	61.02	29.60

SHARKEY CLAY.

The Sharkey clay consists of 3 to 5 inches of a rather dark yellow waxy clay, underlain by a waxy mottled yellow clay to a depth of several feet. In some cases a layer of sand is found at a depth of 4 or 5 feet. The type is locally known as "swamp" land. It is low, wet, and subject to frequent overflow, and is covered with standing water usually until the 1st of June. The local variations in texture are very slight.

Where the type occurs near the foothills of the bluff lands it is of a gray or light drab color and seems to contain considerable silt. This makes it even more boggy than in those areas of heavier clay more remote from the foothills. This peculiar phase is locally termed "buck dough," in reference to the doughy consistency which this soil shows in the roads.

The Sharkey clay occurs in large, irregular tracts in the interstream areas of the delta, forming a central, basin-shaped depression, surrounded by the higher-lying soil types previously described. It is the most extensive type in the survey, forming about one-half of the entire area. On the other hand, it is at present the least important agriculturally, little if any of it being under cultivation.

The Sharkey clay is formed, like the other delta soils, by deposition of material brought down by the flood waters of the Yazoo and Mississippi rivers and their tributaries. Much of the type is subject to annual overflow, while all of it is under water at least once in six or eight years. The areas are flat or basin-shaped, and the rain water as well as the flood water is collected and held for long periods. It is usually July before the soil is dried out enough to allow plowing, and this is too late for cotton planting. Crops requiring a shorter season might be produced on some of the higher areas of this soil, but as yet practically no attempt has been made to utilize it in this way.

The Sharkey clay is covered with a heavy growth of forest com-

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posed of oaks, gums, and other deciduous trees. The undergrowth consists of dwarf palmetto, coarse grass, shrubs, and briers. There was formerly some cypress along the bayous and sloughs, but this has been generally cut out. The timber standing now is said to be better for firewood than for any other purpose. (See Pl. XVII.)

There is no doubt whatever that this soil is very fertile, and there is practically no reason to doubt that with a proper system of levees and drains much of it could be brought under cultivation and made to produce good crops of cotton, rice, and corn. But the cost of such reclamation would be very great and the work so extensive as to be beyond private means. The problem is one for the State or for some corporation of immensely greater resources than any yet formed, at least in this country, for the promotion of agricultural projects.

The areas of Sharkey clay are said to be somewhat more valuable than a few years ago. Tracts are now held at prices ranging from $2 to $10 per acre. The value must probably be ascribed to the standing timber.

The following mechanical analyses show the exceedingly fine texture of this soil:

Mechanical analyses of Sharkey clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7984	3 miles SW. of Satartia.	Dark-gray clay loam, 0 to 5 inches.	3.88	0.18	0.46	0.88	3.10	3.16	44.54	47.16
7986	4 miles SW. of Valley Park.	Mottled brownish clay, 0 to 6 inches.	2.34	.02	36	.36	1.32	3.70	30.74	63.40
7985	Subsoil of 7984	Gray clay with fine sand, 5 to 36 inches.	1.42	08	.50	.40	.94	1.18	32.46	64.14
7987	Subsoil of 7986	Mottled yellow to blue clay, 6 to 36 inches.	1.50	.06	.16	20	1.44	2.02	28.92	66.80

MEMPHIS SILT LOAM.

The Memphis silt loam consists of 8 to 12 inches of brownish-yellow silty loam, underlain by heavier chocolate-brown silty loam. The soil when dry is quite powdery, with a texture not unlike well-ground flour, and when moist it is plastic, but not sticky. The subsoil when dry crumbles into a fine powder, and when wet it is both plastic and sticky, exhibiting some of the properties of clay.

This soil is remarkably uniform in texture throughout both the Cane Hills and Flat Hills regions of the upland, but the depth of the

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soil averages less in the Cane Hills than in the Flat Hills, a difference due to greater erosion in the former region. (See Pl. XVIII.)

In the Flat Hills, however, near the Big Black River, areas are occasionally found in which the soil and subsoil have a grayish tinge and contain many aggregations of dark-brown iron concretions about the size of peas.

In the Cane Hills the surface of the Memphis silt loam is made up of steep, V-shaped gullies and stream valleys, between which hundreds of very narrow ridges and cross ridges rise to a height of from 50 to 150 feet. Often the tops of these ridges are only wide enough to accommodate a wagon road, while rarely are they as much as one-fourth of a mile in width. Only about 15 or 20 per cent of the Cane Hills is cultivated. The fields are mostly limited to the tops of the ridges. The remainder of the Memphis silt loam in this region is largely covered by a native growth of oaks, hickory, and beech, with an undergrowth of switch cane. This limitation of the cultivated areas is made necessary by the fact that the land on the hillsides washes very badly.

In the Flat Hills, on the other hand, the Memphis silt loam presents a surface only moderately hilly, with no very deeply cut stream valleys and with frequent quite wide expanses of rather flat or gently rolling lands. In this region a larger proportion of the soil is under cultivation, possibly 35 or 40 per cent being worked at present.

The texture and physiographic position of the Memphis silt loam makes it subject to extremely severe washing. Even in the Flat Hills section of the area and in the more level fields large gullies are constantly forming under the action of the occasional torrential winter rains.

The surface drainage of this soil is very good, but although the type possesses a loamy texture water does not readily percolate into it. The rain water is often held in slight depressions many days before it soaks in. On the other hand, the soil retains moisture well, the subsoil being generally quite moist even in dry weather.

The Memphis silt loam is derived by the process of weathering from the unconsolidated yellow silt or loess covering the entire upland area.[a] The loess mantle is from 20 to 40 feet thick and is very uniform in texture, which accounts for the almost entire absence of local variation in the soil.

The Memphis silt loam is not as rich in organic matter as the delta soils. To the proportionally less vegetable remains may in part be ascribed the lower crop yields of this soil as compared with the Yazoo loam or other delta soils.

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[a] For a discussion of the loess as found in this region see Report Field Operations, Bureau of Soils, 1901, pages 365 to 368.

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The principal crop in the uplands, as in the delta, is cotton. Occasional fields of corn, cowpeas, and grass, grown for feed for the work stock, occur, and some vegetables are produced here and there in gardens and for home use. The yield per acre of cotton ranges from about one-half bale to three-fourths bale, and of corn from about 10 to 25 bushels. There is apparently little difference in the yields in the Cane Hills and in the Flat Hills.

Besides the crops grown, to which the soil seems well adapted and of which much higher yields could be secured by the introduction of crop rotation, green manuring, and other established methods, there would seem to be many products suited to the Memphis silt loam. The further introduction of cattle raising, especially in the Cane Hills region, where there are wide areas of woodland suitable for pasture, and the growing of more forage crops for winter feeding on the areas now used exclusively for cotton are suggested as practicable changes in present agricultural practices. The experimental growing of grapes and other fruits is recommended. It is upon a loessial soil that the great vineyards of Germany are established, while apples and pears are being successfully produced on a soil of like origin in Illinois and in other States of the Central West.

Judging from the kitchen gardens, the Memphis silt loam is an excellent soil for truck growing. Sweet potatoes and peanuts also produce well. As yet none of these crops are grown on a commercial scale.

The average valuation of land in the Cane Hills ranges from about $2 to $12 an acre, while in the Flat Hills it is from $5 to $17 an acre.

About 80 per cent of the Cane Hills region supports a heavy forest of white oak, red oak, post oak, hickory, and beech. The oak makes good lumber. Much white oak is sold to barrel-stave factories. In the Flat Hills these same forests occur, occupying perhaps 50 per cent of the area.

The upland is more thickly settled than any of the delta country. The population (about 60 per cent colored) averages about 40 to the square mile. In the delta the average is about 30 inhabitants per square mile, 90 per cent being negroes. This is accounted for by the fact that the hill country is regarded as being more healthful than the delta. Many who own lands in the delta area reside in the uplands. This arrangement was more common during slave times than now, but it still prevails to some extent.

Most of the buildings were built many years ago. The farmhouses range in value from about $800 to $3,000, while the average barn may be worth from about $100 to $500. In addition, there are usually a number of negro cabins worth from $20 to $100 each. The farms range in size from 40 to over 1,000 acres, but the usual size is between 160 and 300 acres.

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The following table of mechanical analyses shows the texture of samples of the soil and subsoil of this type:

Mechanical analyses of Memphis silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7980	½ mile NW. of Bentonia.	Dark-brown silty loam, 0 to 12 inches.	1.20	0.00	0.30	0.26	0.42	1.96	88.48	7.96
7978	¾ mile NW. of Bentonia.	Dark-brown silty loam, 0 to 12 inches.	1.15	.30	.84	.58	.74	2.86	83.80	10.62
7982	6 miles W. of Bentonia.	Brown silty loam, 0 to 6 inches.	.96	.00	.20	.40	.50	2.94	80.16	15.16
7979	Subsoil of 7978......	Brownish-gray silty loam, 12 to 36 inches.	.41	.08	.82	.44	.60	2.58	76.92	18.02
7981	Subsoil of 7980......	Brown silty loam with clay, 12 to 36 inches.	.31	.00	.10	.12	.24	1.70	79.54	18.16
7983	Subsoil of 7982......	Brown silty clay, 6 to 36 inches.	.42	.00	.10	.10	.14	1.18	79.54	18.42

LINTONIA LOAM.

The Lintonia loam consists of the silt washed from the bluffs or uplands and deposited in fans or cone-shaped deltas or terraces along the margin of bottom lands. At the base of the bluffs this material is 12 or 15 feet deep, while where it joins with the delta soils, a distance of from one-half to three-fourths of a mile from the bluff, the depth does not exceed 1 foot. There is little difference between the soil and the subsoil of this type, both being a uniformly textured, dark-brown silty loam, with occasionally a slight admixture of sand.

This soil occurs as a strip about three-fourths of a mile wide skirting the bluff separating the delta from the upland along the Yazoo River and as a well-marked second terrace along the Big Black River. The surface slopes gently away from the bluff. The inclination is nowhere greater than 15 dgrees, and in some places the gradient is so slight as to make the surface appear level. The Lintonia loam is rarely overflowed, except locally by floods in the streams draining from the uplands. The even surface and unbroken slope make the surface drainage very thorough.

As already intimated, the origin of this type is to be found in the transportation of the loess of the bluffs and uplands, principally the former, by erosion. It is a true colluvial or colluvial and alluvial deposit, and whatever differences in texture occur between this and

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the upland soil type, Memphis silt loam, are due to the sorting of particles by the agency of transportation, which is chiefly the rain waters.

As would naturally be expected, the mineral constituents of this soil do not differ greatly from those of the upland soil, though the proportions of both the soluble salts and organic matter are somewhat higher. The yields indicate the superior fertility of this soil.

As with the other soils, the chief crop of the Lintonia loam is cotton, of which the yield per acre ranges from three-fourths of a bale to over 1½ bales. The average yield is probably about 1 bale. Good yields of corn, cane, and grass are also secured. Nearly all of the type is cleared and under cultivation.

The Lintonia loam, as might be inferred, is adapted to a wide range of crops. The usual farm crops, such as cotton, corn, and forage crops, all do well, and the various truck crops, such as sweet potatoes, Irish potatoes, cabbages, melons, etc., also thrive. Strawberries, raspberries, peaches, plums, and pears are grown to some extent and seem to flourish. The cultivation of these crops might be profitably extended. The Lintonia loam is highly esteemed by the farmers.

The following table of mechanical analyses shows the texture of samples of the soil and subsoil of the Lintonia loam:

Mechanical analyses of Lintonia loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7976	3¼ miles W. of Phœnix.	Dark-brown silty loam, 0 to 10 inches.	1.64	0.20	0.42	0.84	6.10	7.60	76.40	8.44
7974	1 mile S. of Bentonia.	Dark-brown silty loam, 0 to 10 inches.	.76	.04	.62	.62	1.18	7.38	81.58	8.80
7977	Subsoil of 7976	Brown silty loam, 10 to 36 inches.	.31	.20	.50	.36	4.90	11.90	74.22	7.90
7975	Subsoil of 7974	Brownish-gray silty loam, 10 to 36 inches.	.51	.00	.48	.50	1.14	3.60	76.10	18.12

MEADOW.

The Meadow type of this area consists of a dark, rich, silty loam 8 to 15 inches deep, underlain by a lighter-colored subsoil quite similar in texture to the soil. In the Cane Hills the type often has a slight admixture of fine sand and occasionally some gravel, derived from the Orange sand stratum. In the Flat Hills the type is quite uniformly

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a rich, dark-brown silty loam, the subsoil being in some cases drab colored instead of brown, and containing considerable quantities of brown and black iron concretions.

The greatest expanse of Meadow occurs along the Big Black River, while small areas occupy the small, narrow stream bottoms occurring in the upland area.

The Meadow areas are flat, low-lying, and wet, and by reason of their location are subject to overflow from the sudden rise of streams following a heavy rainfall.

When the streams are at their normal stage the drainage of this type is very good. On the other hand, it is always sufficiently moist from seepage waters that come from the hills.

The Meadow areas have been formed by sediments deposited by the streams. Most of the material has come from the uplands and consists of silt and clay. In the Cane Hills region, however, where the streams have in many instances cut entirely through the loess and the Orange sand down to the blue Eocene clay, some trace of gravel and sand has been intermingled with the finer materials. The depth of this flood plain material usually varies from 3 to 6 feet.

The minerals composing the Meadow are quite similar to those of the Memphis silt loam. The Meadow, however, by reason of the processes of its formation and its low-lying position, contains more decayed vegetable matter, and is therefore a more fertile and productive soil.

Cotton and corn are the principal crops grown on the Meadow. The yield per acre of the former averages 1 bale; of the latter, about 30 bushels. Grass and other forage crops also produce well, yielding from 2 to 5 tons per acre in two or three cuttings. Cane yields about 300 gallons of sirup per acre on these lands. Excepting the large area along the Big Black River, most of the type is cleared and cultivated. The original forest consisted largely of gum, sycamore, and poplar, these being still found on areas unsuitable for tillage.

Under normal conditions the crops just named are well adapted to this soil type. The fact that so much of the Meadow lands is cleared and cultivated indicates their value. In the Cane Hills region this type and the tops of the Memphis silt loam ridges are the only areas admitting of cultivation. The meadows here, lying as they do in the bottoms of deep, narrow gullies and valleys, are often considerably shaded, and cotton has a tendency to rust badly. The very deep and narrow bottoms are often used for permanent pasture, while some are still forested.

In the Flat Hills, where the stream bottoms are not so deep, and therefore less shaded, the cotton suffers less injury from rust and other fungous diseases. Crops in the Meadow areas are also always subject to damage by flooding.

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AGRICULTURAL CONDITIONS.

The farmers of the Smedes area consist of whites and negroes in the proportion of about 1 to 9 in the delta section and about 2 to 3 in the upland. The greater number of the negroes live from hand to mouth, giving little heed to the future and spending their earnings freely to satisfy some present whim or appetite. A spirit of idleness is said to be on the increase among them. Even when it is most urgent that cotton should be picked, many stop work on Friday and do not return to work again until Monday or Tuesday. It is, therefore, not strange that the negroes as a whole are not in a prosperous condition. There are, of course, exceptions, but they are rare. Some negroes own the land they till, but the vast majority of them are tenants.

The white farmers, on the other hand, usually own their lands and as a whole are in a fairly prosperous condition, while some are wealthy. There are only occasional instances of actual poverty among the whites.

There are few foreigners in the area, most of the planters being descendants of sturdy English stock that settled here during colonial times. Many of these became large landowners through the liberal grants of the English Government.

The civil war was disastrous to the agriculture of this region, and the effects of that struggle have hardly been effaced as yet. Retarded by this and hampered by the unreliability of the negro labor and insufficiency of the school system, the agricultural industry has not made the advance that the naturally fertile soils would seem to justify. Men of means hesitate to invest capital under such untoward conditions.

The following tables, compiled from records of the Twelfth U. S. Census, present some interesting facts of general application to the area:

General farm statistics for the State and also for five counties parts of which come within the limits of the Smedes area.

Division.	Proportion in delta or upland.	Number of farms.		Acres in farms.			
		Total.	With buildings.	Total.	Improved.	Average size.	Per cent improved.
The State	About one-sixth in delta and five-sixths in upland.	220,803	211,299	18,240,736	7,594,428	82.6	41.6
Issaquena County	Entirely in delta area.	1,646	1,593	90,676	55,052	55.1	60.7
Sharkey County	do	2,043	2,019	80,362	61,115	39.3	76.0
Warren County	About one-third in delta and two-thirds in upland.	4,058	3,649	221,851	116,942	54.7	52.7
Yazoo County	About one-half in delta and one-half upland.	6,741	6,549	428,145	238,098	63.5	55.6
Madison County	Entirely in upland	4,717	4,565	341,388	218,172	72.4	60.7

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General farm statistics for the State and also for five counties parts of which come within the limits of the Smedes area—Continued.

Division.	Values of farm property.				Value of product not fed to live stock.	Expenditures.	
	Land and improvements (except buildings).	Buildings.	Implements and machinery.	Live stock.		Labor.	Fertilizer.
	Dollars.	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*
The State	114,856,660	37,150,340	9,556,805	42,657,222	90,743,658	3,917,256	932,098
Issaquena County	1,456,110	413,870	110,085	334,035	887,071	34,702	786
Sharkey County	2,222,100	463,300	125,510	416,466	1,356,880	81,260	1,690
Warren County	2,176,090	627,210	182,500	706,581	1,794,695	144,370	1,960
Yazoo County	4,749,260	1,251,420	346,720	1,323,842	3,493,122	239,850	7,320
Madison County	2,600,660	882,420	180,060	878,489	1,860,708	117,190	8,790

The above table shows that the counties in the delta area use very much less fertilizer than those in the upland. This is accounted for by the fact that the delta lands, already fertile, are sufficiently enriched by the frequent floods to maintain their fertility.

The figures showing the average size of farms are very misleading. This results from the tabulation of the patches farmed by negro tenants in 20 or 40 acre tracts as farms, whereas one white man may own a half-section or a section of land on which a dozen negro families may have holdings. Looked at from the standpoint of ownership, the average size of farms lies between 160 and 300 acres. Tracts of 500 to 2,000 acres are probably more often found in the delta than in the upland, and the lower average size in the delta, as given by the census, indicates only the greater extension of the negro tenant system in that part of the area.

The figures relating to condition of tenure are not available by counties, but for the State at large they show that the percentage of renters among the negroes is much greater than among the whites, both, however, being quite high. Of the whites, 62.5 per cent own their land, while but 14.3 per cent of the negroes are landowners. The manager class is relatively small, but is believed to be on the increase.

In the area surveyed, lands are rented both on a cash and a share basis. The method most commonly practiced is to rent the land at the rate of $5 per acre. The landowner then supplies the tenant with the necessary provisions until the crop is harvested and sold. The rent of land and bill for provisions and other necessaries are then deducted from the amount realized from the sale of the crop, and any proceeds remaining go to the tenant. Often the tenant is in debt at the end of the season, owing in part to his improvidence, the higher rate he has to pay for his necessaries by reason of his running his account for a year or more, or to the low price of cotton. Greater thrift, enabling the tenant to work on a cash basis, would undoubt-

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edly be of marked advantage to himself and to all concerned. It is, however, very unlikely that a change in existing conditions will be brought about for many years to come.

Cotton is the one great staple and the money crop of the area, and nearly all farm operations revolve around its production. Long-staple cotton is usually grown on the richer lands, while on the thinner lands the short staple is grown. The long staple brings from 10 to 15 cents per pound when the short staple brings from 7 to 9 cents. However, the yield per acre of the former is less, and it is more susceptible to adverse conditions than the short-staple cotton.

Some corn, oats, and hay are grown. Small fruits, some orchard fruits, and truck crops are also grown, but only for local use. The production of these crops might be extended with profit. In the upland section the fattening of cattle is already assuming some importance, and an extension of this industry may be looked for.

Good corn crops are not, as a rule, secured in the Smedes area. The low rate of yield is apparently due more to lack of proper preparation of the seed bed and to lack of proper cultivation than to any deficiency of the soil or climate. It would seem that the methods employed so successfully in producing corn in Ohio, Illinois, Minnesota, and the Dakotas might be used with success here.

There is frequently a shortage of corn and other feed stuffs in the area, and the work stock have to be fed on corn brought into the area from other parts of the country. This feed is generally expensive, and this alone should impress the farmers of this section with the importance of modifying their field methods sufficiently at least to provide subsistence for the live stock carried on the plantations.

The adaptation of soils to crops has not been worked out to any great extent in the area. Cotton is grown on all the soils, and there is so little diversification that the special capabilities of the different types have not been experimentally determined. The subject has been treated of in the description of the soils, but it is so important a part of the soil survey that a recapitulation of the crops and crop possibilities of the several types will be given here.

The Yazoo sandy loam, by reason of its lighter texture and its location on higher ground next the streams, apparently is one of the best in the area for the production of small fruits and truck crops. The rate of yield of cotton, about three-fourths of a bale per acre, is not as high as for the other delta soils; and although with proper rotation of crops this rate could be materially increased, yet, since the area of this type is relatively small, it would seem as if it might be used almost entirely for truck crops and small fruits, while cotton could advantageously be confined to the heavier soils, more nicely adjusted to its production.

The Yazoo loam is also adapted to truck crops, but is better for

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cotton than the Yazoo sandy loam. It is also a better soil for corn and grass, and it could be advantageously devoted more largely to the production of forage crops.

The Yazoo clay is the typical cotton soil of the delta, but it is also well adapted to corn, oats, the grasses, cowpeas, and other crops of this character. Only in rare cases, and then only for a few kinds of vegetables preferring heavy soils, could this soil be profitably used for truck growing.

Very little of the Sharkey clay is cleared and tilled. If diked and drained, this soil should be valuable for rice growing, as well as for cotton and general farm crops. The type has undoubtedly possibilities that will be developed when the demand for land for farming purposes becomes greater. For the present the standing timber forms its chief value, and some rational system of forestry might be successfully practiced even without the cost of reclamation. Poplar lumber is in great demand and brings a high price in the market, and it would seem as if this tree, which is of rapid growth, might be grown on this type with profit.

The Memphis silt loam, the principal soil type of the upland, in the Cane Hills is well adapted to grazing cattle, sheep, and goats. The native switch cane is the forage depended on at present, but this could be supplemented by growing Bermuda grass, Japanese clover, and alfalfa. Fruit would do well here, and the grape industry is one of the untried possibilities. In the Flat Hills, also, the industries already named should prosper on the Memphis silt loam, and in addition truck growing might be introduced. At present the soil is used chiefly for cotton.

The Lintonia loam apparently would be an excellent soil for trucking. Berries, peaches, and pears can also be produced in abundance. The staple crops of the area give good yields on this soil.

The Meadow type, occurring as it does as bottom land along the small streams of the upland, is valued mostly for growing cotton, corn, and grass. The areas too narrow or difficult to till are used as permanent pasture or allowed to remain in forest.

Both rail and water transportation are available to the farmers of the Smedes area. The Mississippi, Yazoo, and Big and Little Sunflower rivers and some of their branches are used for shipping cotton and other crops to market from the delta area. A through line of railroad traverses the Deer Creek region of the delta, connecting with Vicksburg and other points. In the upland section a railway passes through Bentonia, connecting with Jackson, Memphis, and other important markets. In addition to this other lines are being projected through both upland and delta regions; and if these materialize, they will go far toward effecting the needed diversification of crops.

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The wagon roads of the delta are very bad during wet weather, and even in the upland the roads are not much better.

There are practically no local markets in the area. Only a few small towns, with populations ranging from 20 to 100, are situated within it. These create little or no demand for truck, small fruits, or poultry products. They serve, however, as centers for merchandising and cotton buying. Such places, when situated on a railway or navigable river, are the scene of much activity during the movement of the cotton crop, and throughout the year the trade in general merchandise is often very heavy. Local merchants often acquire considerable cotton in trade for supplies. Some of the cotton grown in the area is shipped to Yazoo City, where there is a compress, and some goes to Jackson and Vicksburg, but the great bulk of the crop is shipped by boat and by rail directly to New Orleans.

On the whole, the area possesses great undeveloped possibilities. With an increase of population and the introduction of better labor or the better education of the present laboring class, trucking, fruit growing, stock raising, and other industries will doubtless be introduced and prosper.

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SOIL SURVEY OF THE BRAZORIA AREA, TEXAS.

By FRANK BENNETT, Jr., and GROVE B. JONES.

LOCATION AND BOUNDARIES OF THE AREA.

The Brazoria area lies entirely within Brazoria County and covers 845 square miles, or 540,800 acres, comprising about three-fifths of the total area of the county. It is bounded on the north by Harris County, a part of its northeastern boundary is formed by Galveston

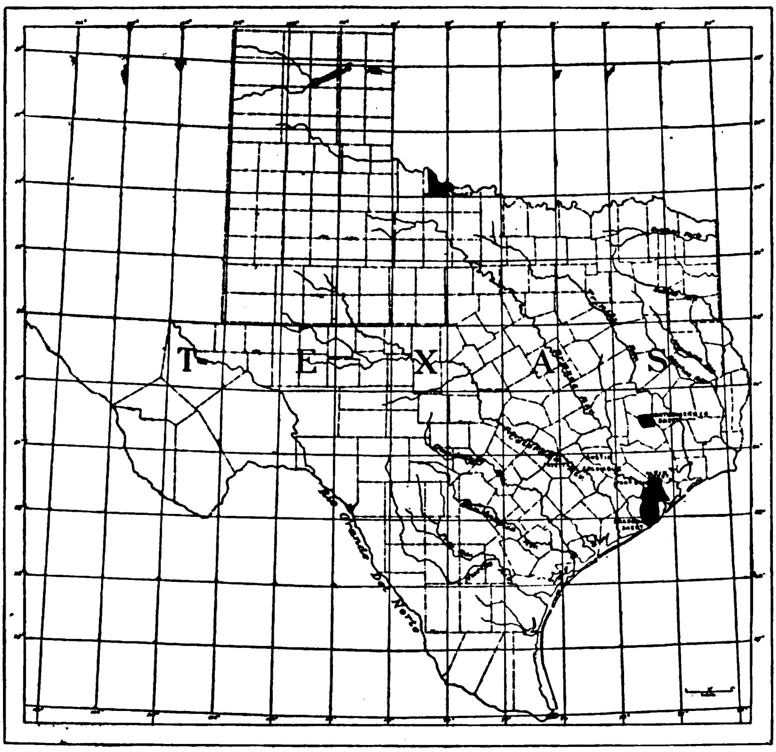

FIG. 9.—Sketch map showing areas surveyed in Texas.

County, and a part of the western by Fort Bend County and the Brazos River. The soil map is platted on a base made by the party in the field, no satisfactory published map sufficiently accurate for the soil survey work being procurable at the time the party went out. The soil map is divided into two sheets. The upper, called the Alvin sheet,

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covering about half the survey, lies wholly on the east side of the Brazos River; the lower or Brazoria sheet comprises territory on both sides of the river, having for its western boundary the San Bernardo River, and reaching south to the Gulf of Mexico. (See fig. 9.)

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Brazoria County was settled in 1823 by a colony under the leadership of F. Austin, whose father secured from the Mexican Government the first concession looking to colonization of the country. The elder Austin died before his agreement was carried out. The grant was very liberal, and allotted to each head of a family one league or 4,428 acres of land. Three hundred families were brought into the country by Austin. The most of these colonists landed at the mouth of the Brazos River, and settled on this river or its tributaries up as far as 20 miles above Old Washington. The most of them preferred lands along the canebrakes on account of the fertility of the soil. In order to prepare the soil for the planting of corn and tobacco—the crops at first grown—the cane was cut and burned. The Mexican Government limited the production of tobacco and stipulated that it should be grown only for home consumption.

About 1826 some cotton was grown, but not until 1830 was the cultivation of this crop extensively undertaken. Ten years later it had developed into quite an industry. In 1840 sugar cane was introduced, and in about seven years it had become one of the leading agricultural products of the county. At this time there were ten or fifteen large sugar mills in the county, and some large plantations made annually as much as 1,200 hogsheads of sugar. The industry grew very rapidly and production was so greatly increased that the price of molasses fell to such a degree as to make its production unprofitable. During this period of depression molasses was fed to stock or allowed to go to waste.

The cotton and sugar-cane industry developed very rapidly up to 1860, at which time Brazoria County produced more than any other county in the State. Cattle were introduced in 1826, the prairie being used for cattle and the bottoms along the Brazos River for general farming. Soon the cattle men had herds ranging from 100 to 5,000 head. In 1848 cattle were worth from $4 to $5 per head, and the price, with minor fluctuations, gradually rose until 1881, when they were worth $20 per head.

The prairie lands were considered of very little value for agricultural purposes up to about 1880 or 1885, when the pear and truck industries were started. Before this these lands sold for from 50 cents to $3 an acre, while the fertile bottoms of the Brazos brought from $20 to $40 an acre.

The greater part of the products of the county up to 1870 was shipped to Galveston and New Orleans.

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CLIMATE.

The climate of the Brazoria area is that of the warmer temperate zone. The temperature is high in summer, and the winters are so mild that roses bloom practically the year around. Gulf breezes moderate the heat of summer to some extent. Occasionally in winter a north wind brings in a short period of comparatively cold weather, but such periods rarely extend over two or three days.

The rainfall is sufficient for ordinary crops, but in many seasons it is unevenly distributed, an excess of precipitation being succeeded by periods of severe drought, often resulting in great loss of unirrigated crops.

The following table shows the normal monthly and annual temperature and precipitation as reported by the Weather Bureau station at Columbia:

Normal monthly and annual temperature and precipitation.

Months.	Columbia.		Months.	Columbia.	
	Temperature.	Precipitation.		Temperature.	Precipitation.
	°F.	Inches.		°F.	Inches.
January	54.0	4.45	August	82.1	3.47
February	57.3	3.10	September	75.5	5.13
March	62.5	2.39	October	69.2	2.84
April	70.1	2.34	November	55.4	3.32
May	75.2	3.02	December	56.6	2.58
June	80.1	4.60	Year	68.4	40.53
July	82.2	3.29			

The following table shows the first and last occurrences of severe frosts for a period of nine years, but it must be borne in mind that these dates do not represent so much the opening and closing of a winter season as the sporadic and temporary conditions of cold produced by the northers that now and then sweep in from the colder country in higher latitudes:

Dates of killing frosts.

Year.	Columbia.		Year.	Columbia.	
	Last in spring.	First in fall.		Last in spring.	First in fall.
1893	Jan. 20	Nov. 15	1898	Mar. 4	Oct. 27
1894	Feb. 26	Dec. 27	1899	Feb. 14	Dec. 16
1895	Mar. 2	Nov. 20	1900	Mar. 2	Nov. 12
1896	Feb. 15	Dec. 2	1901	Mar. 6	Dec. 3
1897	Mar. 24	Nov. 18			

PHYSIOGRAPHY AND GEOLOGY.

Brazoria County, bordering on the Gulf of Mexico and extending inland a distance of about 35 miles, lies entirely within the Coastal

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Plain. For the purpose of description the area is separated into two physiographic divisions—the treeless prairie and the Brazos alluvium. The flat, open prairie is underlain by the Port Hudson formation, composed of yellow or drab clays, and often appears black on the surface from a combination of calcareous and organic elements. The yellow clay often appears on the surface. It contains a large amount of lime nodules. Beneath the clays, at a depth of from 15 to 30 feet, is found a stratum of very fine white sand. Even in the very driest seasons water can always be obtained from this stratum, and it is usually under sufficient pressure to rise within a few feet of the surface. Half fossilized shells have been found in these clays which are identical with those of crustaceans now living in the Gulf. This tends to support the supposition that the conditions of climate, etc., at the period when these deposits along the coast were formed did not differ materially from the present conditions, the only changes being in the relative level of the land and sea.

This open prairie region has a rise in elevation, going inland from the Gulf, of about 1 foot to the mile. It is interspersed with sand ridges of a very peculiar character. They consist of sand mounds from 10 to 20 feet in diameter and from 2 to 3 feet in height. It seems that a satisfactory explanation of this formation has never been given. One theory is that these mounds were formed through the agency of gas pressure, and this theory has perhaps been strengthened by the discovery of oil underlying the county. It is notable that most of the oil wells are on the highest elevations of these ridges. However, oil has not been found in paying quantities.

The alluvium, which is found along the Brazos River, extends back from the river for a distance ranging from 2 to 8 miles. The banks of the river rise from 5 to 30 feet above mean water level, and are composed of stratified yellow and chocolate-colored clays. Quite often a thin seam of black or drab clay is also found. The source of the river is at the foot of the Llano Estacado, and for a distance of 300 or 400 miles it cuts its way through gypsum beds, sandstones, and limestones. Material from these sources is brought down and deposited. The resulting soils are highly calcareous. A section of the river bank shows the top layer to be a yellow or yellowish-gray sand, and this material is being deposited at the present time. Beneath this is a chocolate-colored clay, which quite often contains a thin stratum of black clay. The sand which appears on the surface extends but a short distance from the streams, and then the chocolate clay occupies the surface, forming the lowest portion of these alluvial soils, or the Sharkey clay.

Narrow ridges, ranging in elevation from 2 to 6 feet, have been deposited in these bottoms by the various sloughs and creeks.

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SOILS.

There are eight soil types in the Brazoria area, the actual and relative extent of each of which is shown in the table given below. It will be noticed that over 50 per cent of the area is Houston black clay, the principal type of the prairie region and important as the soil upon which the rice industry is now being developed, while about 30 per cent is included in the Sharkey clay and Galveston clay, two types of poorly drained, marshy, or overflowed lands of little present agricultural value.

Areas of different soils.

Soil.	Alvin sheet.	Brazoria sheet.	Total area.	Proportional extent.
	Acres.	*Acres.*	*Acres.*	*Per cent.*
Houston black clay	209,408	63,168	272,576	50.7
Sharkey clay	32,960	100,096	133,056	24.8
Lake Charles fine sandy loam	27,392	11,392	38,784	7.2
Yazoo sandy loam	4,544	27,328	31,872	5.9
Galveston clay	....	31,168	31,168	5.8
Calcasieu fine sandy loam	18,368	4,672	23,040	4.3
Yazoo clay	3,520	5,632	9,152	1.7
Galveston sand	....	1,152	1,152	.2
Total	296,192	244,608	540,800	....

YAZOO CLAY.

The Yazoo clay is a yellow loam with a depth of 8 inches, containing silt and small amounts of very fine sand. From 8 to 36 inches the subsoil is a stiff chocolate-colored clay. There are small spots of yellow silt loam, varying in depth from 12 inches to 3 feet, which occur quite frequently and are from one-fourth acre to 2 acres in extent. The Yazoo clay occurs as a ridge on both sides of Oyster Creek, following the stream almost its entire length. There are very few breaks in the soil, and it never extends more than one-half mile back from the creek.

This type has been formed principally by Oyster Creek, although the Brazos River has aided in the formation, as material is carried into this creek by the river during the overflows. The principal timber growth is pecan and ash.

This is one of the most desirable soils of the bottoms, as it is very fertile, has good drainage, and is easily cultivated. The most of it is under cultivation at present. Sugar cane is the principal crop grown, but the soil is also well adapted to cotton and corn.

The yield of cane is about 20 tons per acre, and the yield of sugar about 150 pounds per ton. The majority of the sugar mills of the county are located on Oyster Creek, where this soil is principally found.

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The yield of oats ranges from 40 to 65 bushels per acre. With so heavy a yield this crop should be planted more extensively than it is, the acreage now being comparatively small. It would seem that oats could be made more profitable than corn, as it is a crop not so apt to be injured by the droughts quite often occurring during the summer months.

The following table shows the texture of soil and subsoil of this type:

Mechanical analyses of Yazoo clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7777	4 miles SW. of Angleton.	Brown clay loam with sand and silt, 0 to 8 inches.	2.50	0.00	0.14	0.08	0.88	18.54	61.30	18.56
7779	4 miles SW. of Sandypoint.	Light-brown clay loam, 0 to 8 inches.	3.50	.04	.48	.34	.94	13.50	60.32	24.00
7775	3 miles SW. of Angleton.	Yellow clay loam with sand, 0 to 6 inches.	3.83	.04	.60	.36	1.04	15.08	56.86	25.84
7778	Subsoil of 7777......	Stiff brown clay, 8 to 36 inches.	1.97	.02	.26	.24	1.34	14.74	46.56	35.60
7776	Subsoil of 7775......	Stiff brown clay, 6 to 36 inches.	1.35	.02	.08	.12	.54	6.20	55.64	37.02
7780	Subsoil of 7779......	Brown clay with sand, 8 to 36 inches.	1.73	.02	.28	.18	.48	1.74	54.90	42.36

SHARKEY CLAY.

The Sharkey clay is a very stiff, waxy clay to a depth of 8 inches, varying in color from black to a light chocolate. It contains lime nodules, iron concretions, and, quite often, small particles of shell. The subsoil is a very stiff, impervious clay, having the same color as that of the soil. In dry seasons the surface cracks very readily, the cracks being from 1 to 3 inches in width and from 2 to 4 feet in depth. It is locally known as "buckshot land" or "elm flats."

This type occupies about three-fourths of the entire Brazos bottoms, forming the lowest areas, and it is very difficult to drain. Where it can be well drained it is a strong soil for sugar cane, corn, and cotton.

During the inundations of the bottom lands the coarser materials are deposited near the stream, while the finer particles of clay are held in suspension and are carried back from the stream and deposited in the low flats, forming the Sharkey clay. During each deposit a large quantity of leaves and various kinds of vegetable growth is covered over by the sediment, thus making the soil very rich in organic matter. This soil is subject to overflow almost every year, as a rise of

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6 or 8 feet in the river is sufficient to back the water up the small streams and numerous bayous that flow into it. When the water is high enough to overflow the natural terraces along the banks of the river the basin-shaped depressions which form a large part of the Sharkey clay are covered with water from 3 to 10 feet deep. The only outlets for this water are the small streams, and with the slight fall it takes a long time for it to drain back into the river. A thorough drainage and dike system will have to be had before this soil can be utilized to any great extent for agricultural purposes. It is not likely that this will be done for many years, as there are in the bottoms large areas of much more desirable land that remain uncultivated.

The timber growth is principally elm, with a dense undergrowth of vines and various kinds of bushes. The undergrowth furnishes to cattle and grass protection from the cold winds prevailing during some parts of the winter, thus making this land very desirable for winter grazing.

The following table shows the texture of typical samples of the soil and subsoil of the Sharkey clay:

Mechanical analyses of Sharkey clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7815	6 miles SE. of Brazoria.	Waxy gray clay, 0 to 8 inches.	4.01	0.30	2.20	2.16	12.98	8.48	26.26	48.04
7817	1 mile N. of Columbia.	Waxy dark-brown clay, 0 to 6 inches.	1.31	.70	2.02	1.28	3.42	2.42	32.10	59.54
7819	4 miles SW. of Angleton.	Waxy brown clay, 0 to 7 inches.	1.98	.30	1.36	.78	1.92	1.32	26.10	68.42
7816	Subsoil of 7815......	Gray and light-brown clay, 8 to 36 inches.	1.20	1.84	2.46	1.26	3.42	3.00	32.30	55.52
7818	Subsoil of 7817......	Waxy brown clay, 6 to 36 inches.	.22	.54	1.50	.64	1.62	2.30	31.78	62.04
7820	Subsoil of 7819......	Stiff brown clay, 7 to 36 inches.	1.23	.34	.86	.64	2.10	1.80	25.72	68.74

GALVESTON SAND.

The Galveston sand is a light-gray sand, with a depth of 12 inches, containing a high percentage of fine particles of shell mingled with a smaller proportion of larger pieces. The subsoil is a sand of the same character as the soil, the color being a little lighter and the particles of shell somewhat larger.

This soil occurs as a ridge, about one-fourth mile in width, along the Gulf of Mexico, upon which its waves beat. This sand has been

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deposited by the Gulf, and the surface is usually covered with various kinds of shell and driftwood, which the high tides have brought in.

At present there is no part of this soil under cultivation, but with the aid of fertilizers it is known to have produced very good truck and fine watermelons. It is similar to the pineapple soils of southern Florida.

The following table gives the mechanical analyses of typical samples of the soil and subsoil of this soil type:

Mechanical analyses of Galveston sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7799	6 miles SW. of Velasco.	White sand, 0 to 12 inches.	0.23	0.20	1.46	5.10	83.80	8.00	0.06	0.46
7800	Subsoil of 7799	White sand, 12 to 36 inches.	.11	1.34	3.84	9.44	81.68	2.92	.10	.14

GALVESTON CLAY.

The Galveston clay varies from a drab to a yellow-colored clay, occasionally with a thin surface covering of a gray or yellow sand. Generally a large percentage of calcareous nodules is found in the soil.

This type of soil is found near the Gulf, being separated from it by the narrow ridge of Galveston sand that borders the shore. It runs parallel to the Gulf and is from 3 to 6 miles in width.

The part mapped between the Brazos and the San Bernardo rivers forms a kind of basin, having the ridge of Galveston sand on the south, the ridge that follows the Brazos River on the east, and the San Bernardo River on the west. This basin is dotted with ponds and sloughs, which furnish breeding places for myriads of mosquitoes.

This soil has little natural drainage and is wet and marshy even in the driest seasons. The only growth on it is salt grass. It is used only for a cattle range, and is not considered very good even for that.

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The following table shows the texture of the soil and subsoil of this soil type:

Mechanical analyses of Galveston clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7795	1 mile S. of Velasco.	Stiff gray clay, 0 to 6 inches.	4.09	0.10	0.86	0.72	1.82	5.92	43.20	46.44
7797	6 miles SW. of Velasco.	Gray clay, 0 to 10 inches.	2.13	.24	.36	.44	.86	9.00	31.96	56.38
7796	Subsoil of 7795......	Gray and yellow clay, 6 to 36 inches.	.25	.20	.30	.14	.46	4.60	60.70	31.06
7798	Subsoil of 7797......	Brown or yellow clay, 10 to 36 inches.	1.17	.10	.34	.20	.50	6.08	35.16	56.82

CALCASIEU FINE SANDY LOAM.

The Calcasieu fine sandy loam is a compact gray to dark-gray sandy loam, 6 to 18 inches deep, resting on a clay loam which grades into a black or yellow subsoil containing a few iron concretions and large quantities of lime nodules. This soil usually occurs along the streams in broad areas, extending back into the prairie a distance of from one-fourth mile to 2 miles. The areas are commonly raised from 3 to 6 feet above the adjacent prairie, and are thus well drained.

Small white spots free from vegetation occur in this type. The soil in such places is a very fine white sand and silt, from 2 to 4 inches deep, underlain by an impervious yellow clay containing a very large proportion of lime nodules. This yellow clay has been formed by the decomposition of these pockets of calcareous nodules. The spots vary in size from a few square feet to one-fourth of an acre. A chemical analysis shows this soil to contain from a trace up to 0.50 per cent of water-soluble salts, or alkali.

One of the characteristic features of the Calcasieu fine sandy loam are the sand mounds which rise from 10 or 12 inches to 3 feet or more above the surrounding surface. These mounds are from 10 square feet to one-fourth acre in extent. A large part of the area of this soil has been formed through the erosion of these mounds, which are numerous enough in most areas of this type to make the topography slightly rolling.

The Calcasieu fine sandy loam is the principal truck soil of the area. It is upon this soil that the pear industry has been attempted, and which has been generally unsuccessful owing to the general and rapid spread of the pear blight. (See Pl. XX.)

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The following table gives the mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Calcasieu fine sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7769	2 miles SE. of Alvin.	Compact dark-gray sandy loam, 0 to 12 inches.	1.02	0.10	0.44	0.52	13.28	55.38	22.76	7.36
7773	1 mile S. of Angleton.	Dark-gray sandy loam, 0 to 12 inches.	1.46	.24	.46	1.50	23.64	47.14	19.60	7.36
7771	1 mile SE. of Alvin.	Compact dark-gray sandy loam, 0 to 10 inches.	1.29	Tr.	.74	.50	14.60	50.96	25.06	8.02
7774	Subsoil of 7773......	Stiff yellow clay, 12 to 36 inches.	.35	.20	.64	1.10	17.76	35.18	25.50	19.20
7770	Subsoil of 7769......	.....do..............	.84	Tr.	.34	.46	8.94	30.70	24.86	34.44
7772	Subsoil of 7771......	Yellow waxy clay, 10 to 36 inches.	.78	Tr.	.10	.20	7.10	34.18	22.62	35.14

LAKE CHARLES FINE SANDY LOAM.

The surface soil of the Lake Charles fine sandy loam is a heavy black or dark-gray sandy loam, from 6 to 12 inches in depth, containing enough clay to cause a thin crust to be formed on drying. The subsoil is a drab or yellow clay, or in some cases a clay loam, with a depth of 3 feet or more, containing a small percentage of lime nodules and iron concretions.

This soil is usually found in low, broken ridges back from the streams. Alkali spots and sand mounds occur in this type also, but not so frequently as in some of the other soils of the area.

The greater part of the Lake Charles fine sandy loam is used for a cattle range, but some of it is used for farming purposes. It is very easily cultivated, and, on account of its moisture-holding properties, is quite desirable for the production of the truck crops and pears.

This soil type very closely resembles the Yazoo sandy loam in color and texture, but it is a prairie soil, while the Yazoo sandy loam is found in the Brazos River bottoms and is a great deal more fertile. The Lake Charles fine sandy loam is an intermediate type between the Calcasieu fine sandy loam and the Houston black clay. In some cases it is necessary to drain areas of this soil before cultivation, but it usually has satisfactory natural drainage.

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Mechanical analyses of Lake Charles fine sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7805	2 miles SW. of Liverpool.	Dark-gray sandy loam with clay, 0 to 8 inches.	1.88	0.10	0.20	0.50	10.04	27.02	51.26	10.62
7803	3 miles NW. of Angleton.	Dark-gray sandy loam with clay, 0 to 9 inches.	3.26	.28	.44	.18	5.56	29.56	53.02	10.96
7801	4 miles SW. of Alvin.	Gray sandy loam with clay, 0 to 6 inches.	1.31	.02	.26	.14	2.70	37.66	46.50	12.72
7806	Subsoil of 7805......	Stiff gray clay 8 to 36 inches.	1.25	.94	.94	.70	8.66	24.30	51.72	12.52
7804	Subsoil of 7803......	Gray clay with sand, 9 to 36 inches.	1.34	.04	.36	.20	4.30	22.14	49.32	23.64
7802	Subsoil of 7801......	Stiff gray clay, 6 to 36 inches.	1.20	.00	.10	.12	4.68	25.14	42.36	27.60

HOUSTON BLACK CLAY.

The Houston black clay is a black or drab clay from 6 to 10 inches in depth, underlain by a drab or yellow waxy clay containing lime nodules and sometimes small quantities of iron concretions. It becomes compact and cracks into very hard, irregular blocks on drying, but when well cultivated it is quite friable and has a texture much like a clay loam. In very dry seasons the cracks in the lower areas of this type are often from 2 to 6 inches wide and from 3 to 6 feet deep. There is a phase of this soil locally known as "hog wallow," where the surface is rather uneven.

Alkali spots and sand mounds similar to those occurring in the Calcasieu fine sandy loam occur in this type, but the mounds are comparatively rare. In some places, on the other hand, the alkali spots are very plentiful, though of small extent, rarely exceeding 4 feet square. They are usually in depressions from 5 to 10 inches lower than the surrounding soil. (See Pl. XIX.)

The Houston black clay comprises about three-fourths of the area of the treeless prairie, and is found in the parts having the least elevation.

The larger part of this soil is used as a range for cattle, but where it can be well drained it is considered good for general farming purposes. Even the truck crops and pears have been found to do well upon it. Rice has been found to give a good yield, and this soil is doubtless destined to become one of the best rice soils of the country. The yield of prairie grass is very heavy, and a large quantity of it is cut

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and baled each year, the price varying from $3 to $8 per ton. When there is an extended drought in northern and western Texas the prices sometimes range higher.

Quite often there is a very narrow strip of forest found on this soil bordering the streams. This consists of a variety of small oaks, and some areas are covered with a very thick growth of a bush locally called "coffee bean."

The following table gives the mechanical analyses of typical samples of the soil and subsoil of the Houston black clay:

Mechanical analyses of Houston black clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7813	4½ miles SE. of Angleton.	Gray clay, 0 to 8 inches.	2.55	0.00	0.10	0.28	8.48	22.82	51.76	16.62
7811	4 miles N. of Angleton.	Gray clay, 0 to 7 inches.	3.65	.20	.50	.20	6.48	17.80	50.46	24.36
7809	3 miles NW. of Alvin.	Black clay, 0 to 6 inches.	3.88	.20	.56	.34	1.70	6.16	38.44	52.40
7814	Subsoil of 7813......	Stiff gray clay, 8 to 36 inches.	2.21	.00	.04	.28	6.96	17.18	52.06	23.20
7812	Subsoil of 7811......	Gray and yellow clay, 7 to 36 inches.	.79	.60	1.06	.50	2.18	12.16	51.44	32.06
7810	Subsoil of 7809......	Waxy gray clay, 6 to 36 inches.	2.37	.32	.40	.24	1.06	3.82	37.10	57.00

YAZOO SANDY LOAM.

The Yazoo sandy loam is a dark-gray sandy loam to a depth of from 6 to 15 inches, underlain by a drab clay loam containing some sand. Immediately below this is a yellow or light-chocolate colored clay which extends to a depth of 3 feet or more. In some small areas the sandy loam soil extends to a depth of 3 feet or more.

The Yazoo sandy loam occurs in narrow ridges, seldom, if ever, exceeding 1½ miles in width, along sloughs and lakes and along both sides of the Brazos River. As will be seen from the map, no very large areas are found east of the Brazos River, but an extensive area is represented on the west side, occupying a ridge extending from the northern boundary of the Brazoria sheet down to within about 5 miles of Velasco, a distance of about 25 miles.

These ridges are elevated from 1 to 4 feet above the adjacent soil, which is usually Sharkey clay. Some of the sloughs along which this soil is found appear to have been flowing streams at one time, and it is very likely that during the overflows of the Brazos River this material, forming one of the most valuable soils of the Brazos bottoms, was

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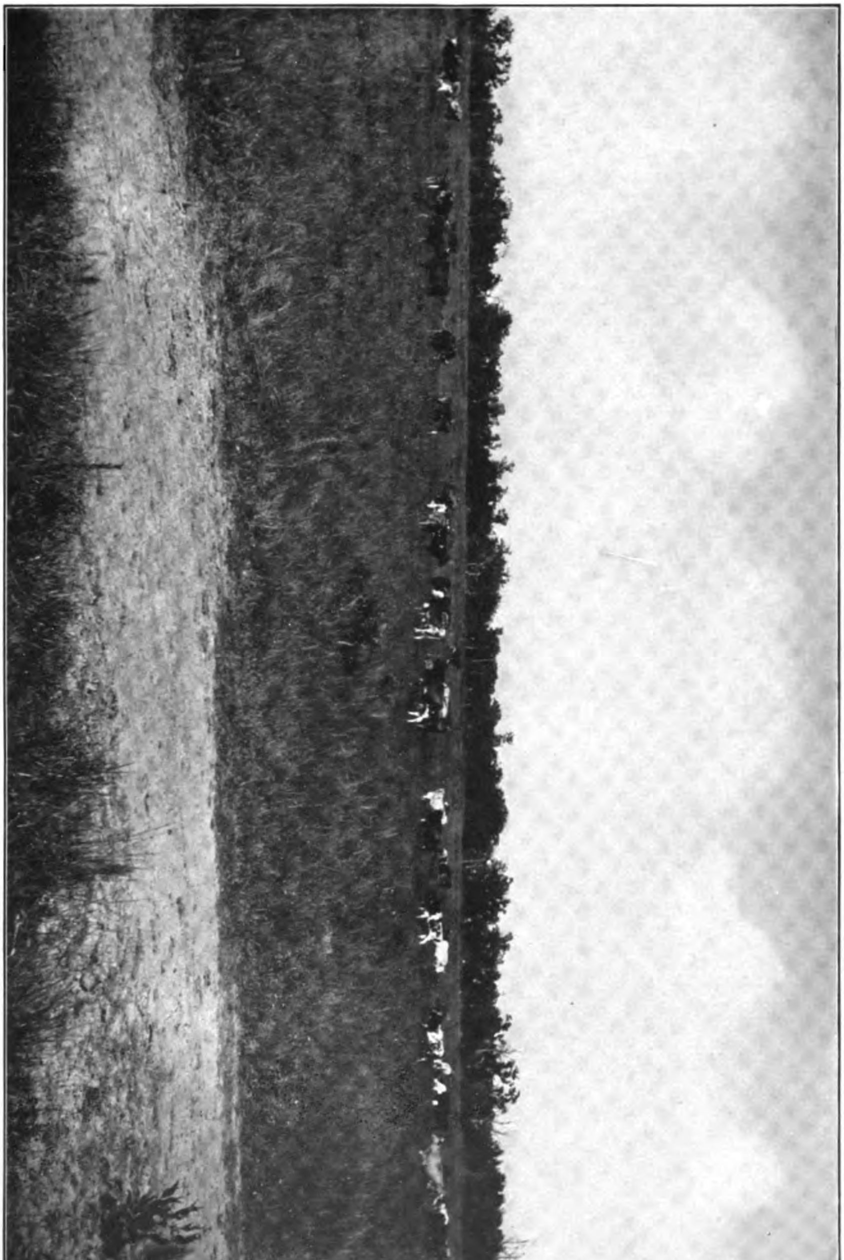

A PRAIRIE OF THE HOUSTON BLACK CLAY WITH ONE OF THE SMALL ALKALI SPOTS IN THE FOREGROUND, BRAZORIA AREA, TEXAS.

This soil has been used as vast cattle ranges, but it is being taken up now for rice culture.

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PEAR ORCHARD AND STRAWBERRIES ON THE CALCASIEU FINE SANDY LOAM, BRAZORIA AREA, TEXAS.

This fruit and vegetable soil occurs on slight ridges in the Houston clay (black prairie). Very few of these pear orchards have escaped the ravages of the pear blight, which has almost wiped out what was once thought to be a most promising and profitable industry.

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carried into the sloughs and deposited along their banks as along the river itself.

The elevation of these ridges gives the soil excellent drainage. A large part of it is not subject to overflow even during the highest water.

The principal timber growth is usually ash, live oak, and pecan. For general farming purposes the Yazoo sandy loam is considered one of the best soils of the area, being very easily cultivated and admirably adapted to sugar cane, corn, and cotton. While very little truck has been grown on this soil type, the indications are that it should be one of the leading truck soils of the county. Irish potatoes have been found to do very well, yielding from 200 to 300 bushels per acre. The crop has to be shipped to market very soon after ripening, as the tubers rot in a short time after removal from the ground. It is very fertile and has at the same time the light, friable texture needed to secure the best results in the production of early truck for the Northern markets. Most of the areas bordering the Brazos River have at some time been under cultivation, but they are now largely under a second growth of forest, principally pecan, and there are large areas where the trees are from three to five years old. If these trees were trimmed—possibly grafted—cultivated, and well taken care of, a handsome profit could be realized from the production of this nut. Up to the present time very little attention has been paid to pecan growing along scientific lines.

The following table shows the texture of the soil and subsoil of this type:

Mechanical analyses of Yazoo sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7789	3 miles NW. of Columbia.	Compact dark-gray sandy loam, 0 to 10 inches.	2.13	Tr.	8.84	0.68	1.04	19.32	68.36	9.58
7791	2 miles NW. of Brazoria.	Dark-gray sandy loam, 0 to 10 inches.	2.29	0.14	.60	.64	15.14	50.30	21.60	11.32
7793	8 miles SE. of Brazoria.	Compact dark-gray sandy loam, 0 to 12 inches.	1.99	.16	.74	.44	.90	17.76	68.06	11.48
7794	Subsoil of 7793......	Yellow clay loam with fine sand, 12 to 36 inches.	1.14	.08	.40	.24	.44	14.04	67.80	16.12
7792	Subsoil of 7791......	Yellow clay, 10 to 36 inches.	.26	.70	.80	.26	.88	25.10	49.34	22.00
7790	Subsoil of 7789......	Yellow clay loam with sand, 10 to 36 inches.	1.00	Tr.	.38	.24	.54	13.72	57.00	27.58

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AGRICULTURAL CONDITIONS.

The farming class, as well as all others, have been very unfortunate in the last few years, having suffered from the disastrous flood of 1899 and the storm of 1900, both of which caused the loss of crops and live stock, together with a vast amount of other property. The boll weevil also made its appearance in this area about four years ago, and has decreased the yield of cotton very rapidly. Soils that produced on an average from 1 bale to 1½ bales of cotton per acre will to-day only yield from one-fourth to one-half bale. The towns of Brazoria and Columbia four years ago shipped from 4,000 to 5,000 bales of cotton annually. At present they are shipping from 400 to 500 bales. For this reason very few of the cotton gins that were destroyed by the flood and storm have been rebuilt, as the product would be too small to supply the great number of gins the county once had. The cotton acreage is decreasing very rapidly each year.

Sugar cane is to a certain extent gradually taking the place of cotton, and the sugar mills are being rebuilt. It will require the investment of immense capital to cultivate all the cotton plantations in cane, and for that reason if for no other it will take many years to entirely replace the production of cotton.

When cotton was extensively grown it was difficult to get labor on the cane plantations, as the negro considered the work harder, but at present labor is more plentiful.

There are seven sugar mills in the county. The plantations that own their mills usually plant from 500 to 1,000 acres in cane. The small farmers either sell their cane to the sugar mills or else make it into sirup by means of small mills run by horsepower.

There are several systems of farming employed in the area. When the farm is small it is usually farmed by the owner, but where it is large the owner manages the entire farm or employs an overseer, wage labor being hired by the day or month. Some of the farmers rent a part of their land either on a cash or share basis. Large plantations usually have a store, from which supplies may be obtained by the laborers.

The farms vary in size from 100 to 5,000 acres. Perhaps one-third of the area included in farms may be under cultivation, although on some of the small plantations the proportion ranges from one-half to three-fourths. There are very few plantations of over 1,000 acres. The greater part of the planters own their own farms. Many of the negroes also own farms containing from 10 to 100 acres, and are in a very prosperous condition. The large plantations in the area are gradually being subdivided.

The greater part of the cultivated lands lie in the alluvial bottoms, although there are some small areas tilled in the black prairie section.

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The rice industry promises to give great impetus to the development of the prairie lands. The Houston black clay, which occupies a very large area, is admirably adapted to the cultivation of rice. The first rice was planted in the area about four years ago, and the growers have not been uniformly successful. The failures have been due in part to the cultivation of a crop new to the area by men not skilled in the methods of its cultivation, but chiefly to an insufficient supply of water, which has been drawn in some cases from lakes and bayous and in some from wells. The only irrigation canal of any importance in the area has a length of about 6 miles, taking water by means of a pump from Bastrop Bayou about 4 miles southeast of Angleton. The canal was designed to irrigate 2,500 acres, but on account of incorrect surveys and poor management of the water its capacity is probably about 1,200 acres.

Rice can not be grown on a very much larger scale in the Brazoria area until canals are constructed from the Brazos River. Several such canals have already been proposed and the surveys made, and it is very likely that some of these will be constructed in the near future. When these canals are built there is no doubt that this will become one of the greatest rice regions of the United States, for it has already been demonstrated that the soils are well adapted to the crop and that the product is of fine quality.

There are at present about 3,000 acres devoted to rice culture in the Brazoria area. The yield per acre ranges from 12 to 15 sacks, and the average price per sack in 1902 was about $3.15. Lands adapted to the cultivation of rice, situated where water is easily obtainable, are worth from $15 to $30 per acre, while other prairie lands are held at from $8 to $12 per acre. Such areas are well suited to rice if water be brought to them. Water is near at hand in the water-bearing substratum, but it is difficult to use, as the pumps soon clog with sand which is so very fine that no means has yet been devised to separate it from the water. If this one difficulty could be overcome, irrigation with artesian water would be very successful.

In the vicinity of Alvin trucking has proved quite profitable and the industry is being rapidly extended. Strawberries are the principal crop. All the beds were destroyed by the storm of 1900, and the growers were left in sorry plight, but through public subscription funds were raised for the purchase of plants, and some 800,000 were shipped in in one season and the industry put upon as prosperous footing as before. Thirty thousand crates of berries, valued at $60,000, are shipped annually from Alvin. The varieties of strawberries chiefly grown are the Lady Thompson, Hoffman, Michel's Early, Miner, and Excelsior. Two-thirds of the crop are of the variety first named. While a few berries are shipped to market as early as January, the season really opens about March 1.

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In addition to strawberries, some blackberries are grown for market, the Wilson being a favorite variety. The Rodgers dewberry, taken from a seedling found in the Brazos bottoms, is also an important berry. It is said to be the best blackberry in the United States for shipping.

During an average season about 12,000 boxes, holding one-third bushel, of mixed vegetables are sent to the Northern markets. The average value of such shipments is about $4,000. Not less than $7,000 worth of tomatoes are produced. These are sent to market in four-basket crates, bringing from 90 to 95 cents per crate.

There are about 4,000 acres in pear orchards in the Brazoria area, and a few years ago handsome profits were realized from this industry, but the orchards are becoming badly affected by blight, the trees are dying rapidly, and many orchards have been cut down, having become unprofitable. The Le Conte and Kieffer are the favorite varieties. The latter is more resistant to blight than other varieties, and some orchards are still bearing very well, but in a few years, from present indications, and unless more care is taken of the trees by concerted action, there will be no pear orchards left in the area.

There are three railroads traversing the county: The Gulf, Colorado and Santa Fe Railway, which runs through the northern part of the area; the International and Great Northern Railroad, which follows the eastern edge of the Brazos bottoms, with its southern terminal at Columbia, and the Velasco, Brazos and Northern Railway, a short line extending from Anchor to Velasco on the Gulf. All these roads lie east of the Brazos River, and that part of the area has very good transportation facilities. West of the river the conditions are in this respect very unfavorable to the development of agriculture. The roads are impassable during a considerable part of the year, and the shipping of products is largely dependent upon the small steamers that ply the river and bayous.

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SOIL SURVEY OF THE VERNON AREA, TEXAS.

By J. E. LAPHAM and PARTY.

LOCATION AND BOUNDARIES OF THE AREA.

The Vernon area is within Wilbarger County, which lies upon the northern boundary of Texas and is separated from Oklahoma Territory by the Red River. Though geographically it is in about the middle of the State from east to west, the country is generally spoken of as Northwest Texas, or perhaps more commonly as the Panhandle country. (See fig. 9.)

Wilbarger County is bounded on the east by Wichita County, on the south by Baylor County, and on the west by Foard and Hardeman counties. It is in west longitude 99° and north latitude 34°, and comprises 947 square miles. The area surveyed lies wholly within the county and contains 277 square miles. Vernon lies a little south of the center of the area, which extends northward from that town a distance of 15 miles. The eastern boundary of the area lies 8 miles west of the eastern boundary of the county, which is formed by the 99th meridian. The southern and western boundaries of the area lie 6 and 7 miles, respectively, from Vernon. The Pease River flows through the area from west to east, cutting it into two nearly equal parts.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Little was known of Wilbarger County previous to 1870, except by occasional hunters and explorers. Recognizing the natural advantages of the country, one or two ranchmen sought range for their cattle upon the rich grasses of the prairie in 1873 or 1874. The great National cattle trail, leading from central Texas to Dodge City, Kans., passing through Wilbarger County at the present site of Vernon, and crossing the Red River at Doans, was the scene in 1876 and subsequent years of great cattle drives, aggregating many thousand head annually. In 1885 there were driven through Vernon 300,000 head of cattle, 200,000 head of sheep, and 190,000 head of horses. Single herds in these drives sometimes numbered as high as 5,000 head. There were then herds of buffalo, antelope, and wild horses ranging the prairies of the county.

One of the first farmers to come to the county was the late Judge Doan, who settled near the Red River, at Doans, in 1877. At that time there were not half a dozen settlers in the county. Timber was not available in the vicinity, and nearly all the settlers then lived in dug-

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outs, wooden houses not appearing until several years later. The county was organized in 1881, with only about 50 bona fide residents.

The Houston and Texas Central Railroad was granted one section of land for every 16 miles of railroad built and operated in the State. Choosing this section of the country as one from which to make their selection, they made the original survey of Wilbarger County, receiving half the lands, the alternate sections belonging to the State free-school fund. These school lands were thrown upon the market in 1883 at a price of $1 per acre for unwatered land, and from $2 to $3 per acre for the sections bordering upon streams or having springs or living streams located upon them. The agricultural development of the county was very slow until about 1885, when the Fort Worth and Denver City Railway reached Harrold, in the eastern part of the county. It was continued on to Vernon the following year, then a little place of about 250 inhabitants, including transient cowboys, and in 1887 connections were made through to Colorado points.

The first settlements were made along Pease River and Paradise Creek. The early agricultural products of the county were principally wheat, oats, and corn. At first the heavy loam lands were thought to be the best fitted for general agriculture, and these were in greatest demand, but the experience has been that though naturally richer in plant food, these loams do not resist droughts well, and of late years the more drought-resistant sandy soils have been given the preference. Little cotton was grown in the county until three or four years ago, but it is now fast coming to be one of the staple crops.

CLIMATE.

The climate of the Vernon area is comparatively dry, and is characterized by high winds and light annual rainfall. The temperature through the summer months is generally pretty uniform, averaging about 80° for the months of June, July, and August, with few sudden changes. In the fall and winter months, however, considerable fluctuation is noticed. Cold winds of great severity sweep down from the north without warning, changing the temperature through many degrees in the space of a few hours and causing at times much suffering to men and animals exposed to their force. Accompanied by sleet and snow these "northers" are at times so fierce during the winter months as to cause considerable loss of life to cattle.

During the months of July and August the winds sometimes carry with them the other extreme of temperature, the hot blasts at times resulting in the course of a few hours, or a day, in the total destruction of a crop of corn, wheat, or cotton. The length of the growing season is such, however, that there is often a considerable subsequent growth of vegetation possible before the time of killing frosts. Corn puts forth a sucker growth from which a good forage crop is secured. Small grain is almost always harvested before the advent of these hot

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winds. Cotton is blighted, but if rains fall subsequently a partial crop is secured. It must be understood, however, that hot winds of such destructiveness are not of annual occurrence. A small amount of damage is done by them nearly every year, but it is only once in four or five or more years that they do the greatest damage.

Little specific climatological data for Vernon and the immediate vicinity are obtainable, but the conditions obtaining there are thought to be fairly well represented by the figures given in the subjoined table. The annual precipitation is probably a little high, and it is thought that 25 inches would be nearer correct for Wilbarger County. At Amarillo the precipitation for the ten years ended 1901 averaged 21.56 inches.

In the Vernon area killing frosts often do not occur until December, the frosts of November being usually light. The seeding of small grain is in progress more or less continuously well on into December and sometimes throughout the whole of that month. Ice seldom forms of a thickness exceeding an inch or two at any time during the winter. The snowfall is light, rarely enough to make good sleighing.

Unlike the rainfall in the semiarid region of California, the greater part of the rainfall in this part of Texas occurs in the summer months. There is, therefore, notwithstanding a considerable precipitation, more uncertainty in grain production in the Vernon area than in parts of California areas with a normal rainfall of less than half as much. The dry weather of fall and winter, if but slightly accentuated, makes seeding difficult and often leaves the young plants in a condition unfavorable for enduring the winter season. The same conditions make the selection of suitable forage crops a difficult problem.

Average monthly and annual temperature and precipitation.[a]

Month.	Haskell.		Henrietta.		Rhineland.		Forestburg.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	*Inches.*	*°F.*	*Inches.*	*°F.*	*Inches.*	*°F.*	*Inches.*
January	43.2	0.92	45.0	0.35	42.8	0.86	44.3	1.68
February	46.4	.79	43.6	1.45	43.0	.86	43.9	.66
March	51.0	1.28	54.9	1.46	53.7	2.06	54.6	4.44
April	68.1	1.93	61.8	2.62	63.6	2.54	64.8	3.65
May	73.8	2.61	72.8	3.49	73.5	4.18	71.0	6.92
June	84.3	3.05	80.9	3.11	81.1	3.03	77.1	4.16
July	85.8	2.63	84.7	2.62	84.1	5.08	82.1	5.79
August	84.0	1.57	85.2	2.66	85.3	1.39	78.9	1.62
September	77.8	1.33	78.1	1.78	77.0	2.67	76.2	1.48
October	66.5	.85	66.3	2.00	67.0	2.08	63.6	1.68
November	51.3	1.49	53.2	1.76	53.3	1.79	52.0	2.94
December	45.8	1.73	44.1	1.09	42.7	1.13	46.2	1.92
Year	65.6	19.73	64.2	24.39	65.1	27.59	62.9	35.92

[a] This table has been compiled from fragmentary records, covers different periods of time for different stations, and is not strictly comparable station by station or with tables of normals given for other areas covered by this report.

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PHYSIOGRAPHY AND GEOLOGY.

The Vernon area lies upon the Permian Red Beds, which extend from the bluffs of the Llano Estacado or "Breaks of the Plains" on the west to the black prairie region of east-central Texas. The area is drained by Pease River, Beaver Creek, and Red River. The Red River, although bordering the county on the north for a distance of about 40 miles, receives comparatively little of the surface water except secondarily through the first-mentioned streams. Pease River rises at the edge of the Staked Plains, about 150 miles west, and reaches the Red River about 9 miles east of Vernon, passing in an easterly direction through the county a little north of its center. It drains the larger part of the area surveyed. Its principal tributary is Paradise Creek, rising to the southwest in the adjoining county and emptying into Pease River 2 miles below Vernon. Wild Cat Creek heads to the north of Tolbert and empties into Pease River opposite Vernon. Beaver Creek, a tributary of Wichita River, drains a small part of the southern edge of the area.

In physiography the country is what is generally termed a high, rolling prairie. The prairie billows are for the most part long and gently undulating, with intervening loam plains or plateaus having a nearly level surface. The level of these loam plains is often broken by eroded depressions or "breaks," the heads of incipient streams. These depressions consist of more or less circular areas, having flat floors composed of the basal red clay from which the overlying loam has been removed. Such areas are indicated on the soil map. These floors are usually bare, save for a few mesquite trees which occasionally obtain a foothold. The walls are nearly always precipitous and vary from 3 or 4 to 10 feet in height. The surface water and silty flood wash is transported from these areas by narrow, abruptly incised streamlets.

A prominent physiographic feature of the area surveyed is a high sand ridge extending across the northern part. The southern border of this ridge is about 6 miles north of Pease River, and trends in a direction approximately parallel to the river. From this line the ridge extends north as a broad belt 5 miles wide to the edge of the sheet, and for an undetermined distance beyond. The sand, though covered by grass, is loose textured and hillocky, exhibiting a sand-dune structure. This sand ridge rises to a height of about 100 feet above the level of the surrounding prairie, and it is estimated that its elevation above the river at Vernon is about 220 feet.

The sand is underlain by a soft, calcareous sandstone of medium texture and grayish color. This is more or less interstratified with layers of red clay and red arenaceous shale. A few exposures are to be seen along the bluffs on Red River, in a few stream valleys in the neighborhood of Doans, and to the west of Tolbert, where a quite

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abrupt escarpment appears. This sand is undoubtedly derived from the indurated material underlying it. Appearances would seem to indicate that a large river or body of water, as an estuary, at one time existed here, and that from its shores the winds drifted the sand inland and piled it up into low mounds and dunes. The disconnected counterpart of this range of sand hills is seen on the south side of Pease River. The ridge here is comparatively narrow, and is smoother in outline, possessing less of the dunelike structure seen upon the other side of the valley. South of Vernon a comparatively wide valley has been cut through this ridge by Paradise Creek.

Pease River, when compared with the physiography and drainage system of the county, is a very old stream, and has succeeded in eroding a relatively wide valley. Its northern bank is for the most part formed by a distinct bluff, in the area surveyed, and the river is at present cutting into it. A more or less terraced valley, having an average width of about a mile and a half, has been built up on the south side of the river. Immediately along the stream this is composed of loose, drifting sand, back of which is an older terrace of sandy loam, overlying in a few instances a small amount of stratified gravel.

The immediate beds of Pease and Red rivers are relatively very wide, the former measuring on an average one-fourth of a mile and the latter something over 1 mile. The beds consist of a body of loose, porous, light-yellow, and reddish sand, drifted to a considerable extent by the wind but having a generally level surface. Through this sand the river at normal stage winds in a comparatively narrow stream. In times of extreme drought the water fails altogether in Pease River, and above the North Fork the same is true of Red River. The water in both streams, but more especially in Pease River, is saline from the salt received from the gypsum beds through which it passes nearer its source.

The country lying between Pease River and the sand ridge to the north is covered mainly with a reddish-brown loam, and an extensive area of loam is also found in the southern part of the area surveyed. Covering the loam bluffs on the north bank of Pease River and extending for a few miles up Red River from its junction with the Pease is a sandy loam of much finer material than that seen to the south of Pease River. It is probable that this is a considerably older deposit. It is well developed at Red Bluff and upon the bluff at Doans Crossing, and is found only upon the highest elevations along the rivers. Underlying it at Red Bluff is a deposit of volcanic ash, the only exposure seen in the area. It is believed that this fine sandy loam is largely an æolian deposit, and is possibly more or less modified by the volcanic ash.

The only notable springs in the area are at Doans, in the northern

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part of the sheet. This combined cluster of springs yields a stream about 6 inches wide, which persists throughout the year. The water from them does not reach the river as a surface stream, but sinks into the sands about a mile from its source.

With the exception of a few hackberry, China berry, elm, and stunted cottonwood trees growing along the more constant streams, the only forest growth in the county consists of mesquite trees, found usually upon the heavier loam and clay soils, where they appear generally in patches, sometimes covering a square mile or so, which from a distance look like fruit orchards.

SOILS.

The soils of the area have been classified into six different types, and are described in the following pages in the order of their areal importance.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Vernon loam	62,528	35.3	Vernon fine sandy loam	5,248	3.0
Vernon sand	56,448	31.8	Vernon silt loam	2,880	1.6
Vernon sandy loam	30,592	17.3	Total	177,152	....
Vernon clay	19,456	11.0			

VERNON LOAM.

This soil to a depth of 12 inches is a fine-grained reddish-brown to dark-brown loam. It is mellow and friable, works up easily in the field, and does not clod. The subsoil, extending to a depth of 36 inches, is a light reddish-brown loam, considerably heavier in texture than the overlying soil. It at times contains lime in the form of concretions, and when this is present the subsoil is grayish in color and somewhat sticky in consistency. At from 3 to 6 feet it is underlain by red clay.

There is some variation in the surface soil of this type. About 2 miles northeast of Vernon, near the north bank of the Pease River, there is an area over which the soil is unusually dark in color and more clayey than in the typical section. This phase of the soil shows a tendency to clod to some extent and is not as easily worked as the true type. Farther down the river and lying adjacent to the Vernon fine sandy loam the soil grows decidedly lighter in color and is looser in structure, partaking somewhat of the qualities of the sandy loam.

The greater part of the area of this soil lies to the southeast and east of Vernon. A quite large extent of it is also to be seen to the north of Vernon, lying between Pease River and the areas of Vernon sandy loam.

The Vernon loam occupies the more level and slightly rolling portions of the prairie upland. The contour is always smooth and even

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and presents no abrupt outlines. At the margins of the areas, where contact is made with the Vernon clay, however, there is sometimes seen an abrupt scarp or "break" where the upper 6 to 10 feet of surface has been eroded away, leaving exposed the underlying clay. The streams of the newly forming drainage systems on this type have steep-cut banks and exhibit the arroyo form of erosion so often seen in arid countries. In elevation this type occupies a position next above the Vernon sandy loam and lower than the upland phase of the Vernon sand.

For the most part this soil needs no artificial drainage, though occasional flat or slightly depressed spots are found where drainage would prove of great benefit.

The soil is derived, as are all the soils of the county, from the weathering of the Red Beds of the Permian formation.

Corn, wheat, oats, Kafir corn, and sorghum are the principal crops grown upon the Vernon loam. It is essentially a wheat soil, and is so recognized. When the rainfall is sufficient the yield is from 25 to 40 bushels to the acre, the former being about the average. Comparatively little cotton is grown upon this type of soil.

The Vernon loam seems to be better adapted to the production of wheat than to any other crop so far tried. The uncertainty of securing seasonable rain in the spring, however, makes even this speculative. Several experiments with macaroni wheat are being made in the area, and if as good results are secured in these trials as have met the introduction of this drought-resisting grain in other semiarid regions there is promise of the development of a profitable industry in the Panhandle section of Texas.

The following table gives mechanical analyses of typical samples of this soil:

Mechanical analyses of Vernon loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7743	3½ miles NW. of Vernon.	Fine dark-brown loam, 0 to 10 inches.	1.54	0.02	0.34	0.76	2.12	12.78	74.78	9.20
7745	3½ miles SE. of Vernon.	Friable, fine brown loam, 0 to 14 inches.	1.23	.12	1.98	2.16	4.84	16.64	64.34	9.70
7746	Subsoil of 7745......	Fine reddish-brown to yellow loam, 14 to 36 inches.	.78	.32	1.78	1.76	4.18	14.46	64.82	12.22
7744	Subsoil of 7743......	Heavy loam containing much clay, 10 to 24 inches.	1.00	.06	.32	.84	2.50	11.08	71.24	13.96

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VERNON SAND.

The Vernon sand consists of a loose, incoherent sand of medium texture and a depth of about 18 inches. The river-flat phase sometimes contains a little silty material. The upland phase is at times slightly sticky, probably from the presence of lime carbonate. The grains of this sand are all pretty well rounded. No gravel is present. In color it ranges from a yellow in its least typical phase to a reddish brown, where on the upland it contains some organic matter. The subsoil of the river-flat phase is usually somewhat looser and coarser than the soil, at a depth of 3 feet becoming quite incoherent, while in the case of the upland phase it is generally considerably finer in texture and not uncommonly contains sufficient lime carbonate to make it somewhat plastic and grayish in color. The lime seldom takes the form of concretions.

The most extensive development of the upland phase of the type is found in the northern part of the area, where it occurs as a high ridge 8 miles long by 5 miles wide. To the west and north it continues out of the area to an undetermined distance. South of Pease River a corresponding ridge of Vernon sand extends nearly throughout the area in a line parallel to the river, though the continuity of its eastern extremity is broken.

The lowland or river-flat phase of the type is found bordering both Pease and Red rivers throughout nearly their whole length. Along the Pease it has an average width of about one-half mile on each side, while along the Red River, near Doans, it reaches a width of 2½ miles and extends in one unbroken strip from that point south for a distance of about 9 miles to Red Bluff.

The upland phase occurs as a high, rather abrupt ridge or table-land, and the contour is, especially at the northern part of the sheet, generally hummocky and dunelike. It here occupies the highest elevation in the county. The ridge lying south of Pease River is smoother in outline, but is still more hilly and wavy than the loam soils of the prairie upland. The river-flat phase occupies a position usually from 3 to 6 feet above the rivers, and is level, save for the low dunes which have been piled up on its surface by the winds. These range from 2 to 10 feet in height and are generally covered with a scanty growth of grasses.

The upland areas of this soil are always well drained. That part of the type which occurs at the river level is sometimes, though not often, flooded, but the water table is rather too near the surface for most crops. Local spots in this phase have had enough silt deposited upon them at times of high water to constitute a different soil type, though with a subsoil similar to that of the Vernon sand. Not much of this low-lying phase can be artificially drained.

The soil of the upland phase was probably formed before the rivers

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had reached their present levels and at a time when a very wide river or estuary covered what now exists as the loam upland. The disintegrated material derived from the underlying sand rock was washed up along the shores and carried inland by the winds. In the same manner the Vernon sand lying contiguous to the present rivers is being left behind by the recession of the streams, and is being constantly drifted and piled into dunes by the wind.

Upon the upland phase nearly all the ordinary farm crops are grown, though the principal ones are Kafir corn, sorghum, and cotton. Under the most favorable conditions cotton produces as high as 1½ bales to the acre, though, owing to uncertain seasons, one-half bale is much nearer the average. Excellent stands of corn and Kafir corn are seen growing upon this type, even in quite dry seasons. Some wheat is grown, but the quantity is comparatively insignificant. Apples, peaches, and melons do well on this soil. The greater proportion of the type is used for pasture land, and is covered with a growth of native grasses. The lowland phase of the type is used for little else than pasturage, and is for the most part not adapted to agricultural purposes.

The upland phase of the Vernon sand is well adapted to the culture of cotton and fruit, and during seasons of sufficient rainfall should prove an excellent soil for early truck crops, melons, etc.

The following table gives mechanical analyses of typical samples of this soil:

Mechanical analyses of Vernon sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7755	1 mile E. of Doans.	Loose, incoherent, medium to fine yellow sand, 0 to 18 inches.	0.23	0.00	0.90	8.50	57.70	26.82	4.18	1.30
7753	6 miles SW. of Vernon.	Loose, incoherent, medium reddish yellow sand, 0 to 22 inches.	.45	.02	7.38	24.96	45.26	13.44	5.36	3.58
7751	7½ miles SW. of Doans.	Loose, incoherent, medium yellowish red sand, 0 to 26 inches.	.69	.32	5.50	13.40	35.58	23.60	14.42	7.18
7756	Subsoil of 7755......	Loose, incoherent fine sand, 18 to 36 inches.	.16	.00	.84	7.40	60.30	27.66	1.88	1.26
7752	Subsoil of 7751......	Medium to fine yellowish red sand, 26 to 40 inches.	.40	.10	4.48	11.16	30.08	24.88	21.16	8.14
7754	Subsoil of 7753......	Sticky, medium reddish yellow sand, 22 to 36 inches.	.42	.20	5.76	18.98	46.78	12.92	10.60	9.76

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VERNON SANDY LOAM.

The Vernon sandy loam is a dark red to reddish brown sandy loam, having a depth varying from 12 to 18 inches. While the mechanical analyses show it to be rather fine in texture, the presence of a considerable number of quite coarse quartz grains makes the soil appear coarser in texture than is actually the case. The soil is mellow, friable, and easily worked. The subsoil down to a depth of 36 inches grows gradually heavier in texture. The color varies from a red to a brown, and at times is slightly gray at 36 inches. This grayish color is probably due to the presence of a small amount of lime carbonate, which also gives the subsoil a sticky consistency. At a depth of 6 feet a small amount of waterworn gravel is sometimes seen. This is not always present, and the stratum is so thin and the gravel so much scattered that it exerts little influence upon the water-carrying capacity of the soil. The soil, taken as a whole, is quite retentive of moisture, and crops grown upon it withstand drought well.

The Vernon sandy loam reaches its highest development along the south side of Pease River, where it forms a continuous strip entirely across the area surveyed. Little of this type is seen on the immediate north bank of the river, though a considerable area of it is found bordering the upland sand hills farther north. If the sand hills be sloping, the Vernon sand and Vernon sandy loam are often found to grade imperceptibly into each other, forming a zone half a mile or so wide over which the soil partakes somewhat of the characteristics of both types. A few areas of the Vernon sandy loam occur in isolated patches in depressions on the sand hills to the south of the river.

In the Pease Valley the soil is found at an elevation intermediate between the river level and the prairie upland, and the greater proportion of that part of it which lies along the river to the east of Vernon occupies a pretty well defined bench or terrace, though at one or two places the type encroaches upon the lower level. The area of the soil found in the northern part of the survey occupies a higher elevation, resting upon the loam upland just below the sand hills.

The soil is generally well drained, lying in a sloping position, as a rule, and having few depressions in it. The subsoil is more or less porous and allows of the ready percolation of the excess surface water. Artificial drainage is seldom necessary.

In the Pease River Valley the soil was formed when the river was much wider than at present, and is probably largely alluvial in origin, the sands being deposited along the river's edge and drifted inland by the wind and there mixed with the heavier Vernon loam. In other parts of the area it was formed, and is still being formed, by the washing of the Vernon sand down over the lower-lying loam, resulting in the intermixture of the materials of different texture.

While the yield per acre of wheat does not amount to as much on

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this type as on the heavier Vernon loam, yet with the uncertain seasons the crop is surer. Corn, Kafir corn, and cotton yield well, and with sufficient rainfall the latter will reach a bale to the acre in some cases. Oats are very successfully grown upon this type, yields of 65 to 80 bushels having been secured, though 40 bushels is about an average crop under good conditions.

This type of soil is generally considered to be very drought resistant and is adapted to the growth of almost any of the ordinary farm crops. It is also a good soil for potatoes and other vegetables and for melons. There should be little trouble in growing alfalfa successfully.

The following table gives mechanical analyses of typical samples of this soil:

Mechanical analyses of Vernon sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7757	3½ miles SW. of Doans.	Medium reddish-brown sandy loam, 0 to 15 inches.	0.77	0.24	8.84	17.78	25.38	22.56	13.22	11.20
7759	5½ miles NE. of Vernon.	Fine sandy loam, 0 to 24 inches.	.60	.10	1.26	3.04	10.61	53.14	20.46	11.20
7760	Subsoil of 7759.....	Fine red sandy loam, 24 to 36 inches.	.22	.00	1.24	3.04	12.10	41.92	28.32	12.86
7758	Subsoil of 7757.....	Medium to fine, sticky sandy loam, 15 to 36 inches.	.27	.40	7.70	15.30	22.90	19.30	16.38	17.40

VERNON CLAY.

The surface soil of the Vernon clay is a red clay or heavy clay loam with a depth of about 9 inches, in some localities containing a small percentage of rounded quartz gravel. In the eroded depressions the soil contains little organic matter, as with every rain it is subjected to the flood wash of the underlying basal clay, and can hardly be considered a soil in the ordinary sense of the term. The subsoil is a heavy, sticky red clay, extending to an undetermined depth. It often contains waterworn gravel in which a precipitate of gypsum is not uncommonly found. The gravel varies in size up to 3 or 4 inches in diameter, and mixed with this are occasional pieces of silicified wood. Interstratified with the red clay underlying this type of soil are occasional bands of red arenaceous shale.

The largest and most continuous body of this type found during the present survey is in the southeastern part of the area. North of Pease River and to the south of Tolbert a quite extensive area of it also occurs.

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The type is best represented in the first-mentioned locality, where it occurs as broken and eroded depressions in the prairie, with intervening long sloping hillsides covered with a growth of mesquite trees and curly mesquite grass. At this place it occupies a position just to the south of the divide between Beaver Creek and Pease River, and at the headwaters of the tributaries of the former stream. In other parts of the area it occupies erosion depressions at the sources and along the margins of newly forming stream courses. The landward margins of these depressions are irregular and varied in form, the faces of the walls are abrupt, from 3 to 10 feet high, and bare of vegetation, and the floors, which are usually flat, support a straggling growth of mesquite. The depressions are drained by narrow, deeply incised streamlets, carrying large quantities of the red clayey material down to the larger streams, and becoming dry in a few days after a rain. The barest portions of these areas, upon which no soil exists nor can exist, owing to the frequent washings which they receive from rains, are indicated upon the soil map by diagonal cross lines.

While the floors of these eroded areas are nearly level, they are so hard and smooth that the surface water runs off freely.

The Vernon clay is the underlying basal clay of the Vernon loam, and the soil type results for the most part from a denudation of the Vernon loam. Primarily the soil is derived from the Permian Red Beds.

The soil is very little used for anything except pasture, and because of the comparatively scanty vegetation a larger acreage per head of stock is required for range purposes than in the case of the Vernon loam.

In parts of the area where vegetation has secured some foothold, and there is in the soil sufficient organic matter, wheat might be grown advantageously in seasons of normal rainfall.

The following table gives mechanical analyses of typical samples of this soil:

Mechanical analyses of Vernon clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7741	6¾ miles SE. of Vernon.	Silty clay, 0 to 10 inches.	1.53	0.00	0.36	0.24	1.20	17 88	67.76	12.56
7742	Subsoil of 7741	Fine yellowish-red clay, 10 to 28 inches.	.69	.00	.64	.30	.84	8.50	72.20	17.10

VERNON FINE SANDY LOAM.

To a depth of about 22 inches the Vernon fine sandy loam is a fine brownish-red sand, carrying considerable silt. The individual particles appear much rounded, and in structure the soil is loose and mellow. It works up nicely in the field, and does not form clods nor bake. The subsoil is substantially the same as the soil, except that the color is usually a little lighter in the lower depths. Sometimes, however, the subsoil is somewhat darker and more loamy than the soil until a depth of 3 or 4 feet is reached. At depths of from 4 to 6 feet the material is generally a fine yellowish-red sand.

The type is found bordering the Red and Pease rivers, near their confluence, and extends inland from them for a distance of about half a mile. It occupies the bluffs along the rivers, and is rarely found below an elevation of 40 or 50 feet above their beds. At Doans a small area of it extends from the bluff down onto the bench lying just above the river flat. As a rule the surface is slightly rolling, allowing free drainage.

The soil is believed to be mainly æolian in origin, formed from the sands blown inland from the rivers during some period when their beds occupied a relatively higher position than at present.

Not much of this type is under cultivation, it being used principally for pasturage. This is one of the best soils of the area for wheat, corn, oats, cotton, and other farm crops. Fruit and vegetables would also do well upon it.

The following table gives mechanical analyses of typical samples of this soil:

Mechanical analyses of Vernon fine sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7737	6 miles NE. of Vernon.	Fine sandy loam, 0 to 24 inches.	0.79	0.00	0.68	0.50	2.64	46.74	42.14	6.72
7739	2½ miles N. of Vernon.	Fine, mellow red sandy loam, 0 to 18 inches.	.71	.00	.22	.30	1.18	24.98	66.44	6.88
7740	Subsoil of 7739	Fine dark-red sandy loam, 18 to 36 inches.	.70	.00	.34	.42	1.84	25.24	64.40	7.64
7738	Subsoil of 7737	Fine sandy loam, 24 to 36 inches.	.61	.30	.60	.40	2.48	44.14	41.78	9.82

VERNON SILT LOAM.

The soil, as well as the subsoil, of the Vernon silt loam varies greatly, and ranges from a loose sandy loam to a loam of nearly the character

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of clay. The most of the type, however, is a silt loam to a depth of about 10 inches, underlain by loose yellow sand. At irregular intervals through this sand are encountered thin, sticky bands of silt and clay.

The Vernon silt loam occurs along the Pease and Red rivers and forms but a small percentage of the total soil area mapped. It is found on the river flats, usually near the bluff line, and occupies depressions in the river-flat phase of the Vernon sand.

Owing to their position the drainage of the areas of the heavier phase of this soil would be difficult if attempted. They are wet for some time following rains, the surface being often too impervious to allow free percolation of water through it into the underlying sand.

This soil type is formed from the recently deposited river sediments dropped upon the older Vernon sand. The soil is covered by a rather scanty growth of coarse grasses, and is used only for pasturage. It has little agricultural value except, perhaps, in the case of the more sandy areas occurring near its contact with the Vernon sandy loam. These areas might be drained and made to produce corn and vegetables, and possibly alfalfa, in some localities.

The following table gives mechanical analyses of typical samples of this soil:

Mechanical analyses of Vernon silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7749	5¼ miles NE. of Vernon.	Fine sand to silt, 0 to 10 inches.	0.87	0.06	0.08	0.04	0.28	16.40	72.20	10.72
7747	2 miles NW. of Vernon.	Rather sticky brown sandy loam, 0 to 10 inches.	1.63	.02	.48	1.82	8.10	37.70	40.46	11.32
7748	Subsoil of 7747......	Brown sandy loam to yellow sand, 10 to 36 inches.	.38	.00	.24	.76	4.40	45.44	40.36	8.26
7750	Subsoil of 7749......	Clay, silt, and sand, 10 to 20 inches.	.78	.06	1.14	3.18	11.10	14.92	53.46	16.06

AGRICULTURAL METHODS.

Rotation of crops is not practiced to any great extent in the Vernon area, the desirability of systematic cropping not as yet having appealed to the farmer. Because of the fact that the rainfall and the attendant leaching away of plant food is so much less than in humid climates, rotation is perhaps not so essential, though to a certain extent it is

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always desirable. The farms are easily cultivated, there being no stones or stumps and comparatively few soil washes, and seeding and harvesting are usually done upon a large scale, allowing the employment of the most improved and efficient labor-saving machinery. A great deal of wheat is drilled into stubble fields without previous plowing, harrowing, or other preparation of the soil. With the price of land ranging from $5 to $15 per acre, this method at present brings, perhaps, the largest returns for time and labor expended, but it is not to be commended, and as the country becomes more thickly settled and land dearer more intensive methods must prevail.

The greatest need of the country is irrigation, but water for that purpose, except on a very small scale, does not seem to be available. Underground water seems abundant and can be pumped from depths of from 20 to 40 feet. Small reservoirs might be built to catch the run-off from the hills, but the streams are dry during a considerable part of the year and would furnish an insufficient supply for irrigation purposes.

AGRICULTURAL CONDITIONS.

The people of Wilbarger County, in common with others of northwest Texas, while perhaps not as thrifty and provident as in some sections of the United States, are nevertheless energetic, industrious, and hopeful, and uncomplainingly make the best of what nature has to give them.

The element of uncertainty is proportionally larger in agricultural pursuits in this part of the State than in more humid regions. This is due not only to the absence at times of sufficient and seasonable rains, but also to the occasional disastrous hot winds of the late summer, which sometimes in a few hours almost totally destroy the crops. If, however, sufficient rains follow these winds, a partial crop is often secured before the advent of killing frosts. The native of the Texas Panhandle, however, if overtaken by crop failure, gets along as best he can and hopefully awaits better times. One of the pleasant features of this part of the country is the commendable spirit of social equality existing between people of widely differing wealth. Little account is taken of dollars if a man shows himself to be honest, self-supporting, and independent, and it is no doubt these conditions which have much to do with the contentedness of the people in general and the farmers in particular.

The population of the county is mainly agricultural. Vernon, the county seat, contains but about 2,000 inhabitants out of a total population for the county of about 6,000, and in Vernon live the only people who follow other than agricultural vocations. The other towns of the county are very small, consisting usually of only a store or two and a half dozen houses. The prosperity of the farming class is rather above that usually found in semiarid countries.

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The majority of the farms in the county are worked by their owners, although a few are rented for a crop or money rental. The crop rent received is one-third of the corn or one-fourth of the cotton, while the money rental will average about 50 cents per acre.

The greater part of the land of the county originally sold in lots of one or more sections. Some of the ranchmen of the county have large holdings. One individual owns several hundred thousand acres in the southern and eastern part of the county, and others engaged in cattle raising have ranges of several sections. The average size of farms at present is thought to be about 320 acres.

Farm laborers are fairly abundant and to be had at wages of $1 a day, but during harvest time they receive more. In more permanent employment they receive $20 a month, with board. Cowboys upon the ranches receive from $35 to $40 per month, with board.

While cattle raising is still carried on to a considerable extent, the price of land is becoming too high to make this a profitable industry under natural conditions, i. e., raising the cattle from the calf to maturity with little or no feed except that secured from the native prairie grasses. At present the majority of the farmers are engaged in general agriculture. Of the ordinary farm crops, small grain is found best adapted to the soils of the area, and is given the greatest acreage. In favorable years wheat and oats give large yields, and even in excessively dry seasons from 4 to 6 bushels of wheat are harvested from an acre, so that there is almost never a complete crop failure. Little corn is grown, though considerable Kafir corn and sorghum are sown for feed. Part of this is harvested with binders, and to a part of it the cattle are allowed to run at will, a difference of opinion prevailing as to the relative economy of the two methods of feeding.

Within the last three or four years cotton has begun to be cultivated in the county, and this crop is fast coming to be one of the staples. It does very well upon the sandier soils, giving a yield of from one-half to one bale or more to the acre. Watermelons and cantaloupes are grown very successfully in the area, and these products have a good reputation in the markets of the East.

It is generally recognized that the sandy soils are the more suitable for cotton culture, as well as for fruit, melons, etc., and that, given sufficient rain, wheat gives the largest yields upon the heavier loam.

Transportation facilities in the area are furnished by the Fort Worth and Denver City Railway, which passes through the northern part of the county, and by the Blackwell, Enid and Southwestern Railway, which connects Vernon with Oklahoma points. The former line affords direct connection with Fort Worth and southeast Texas in one direction and with Denver and important Colorado points in the other. Neither the Red River nor the Pease River is a navigable stream. The majority of the wagon roads of the county are good, though but little

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is done to keep them in repair. Upon the sandy soils they are unavoidably soft, and upon the loam soils they are at times, during unusual rainfall, almost impassable. A little intelligent drainage would put many dollars in the pockets of the farmers who are compelled to haul loads over these roads. Pease River is so wide, the sands are so treacherous, and the currents so shifting, that a bridge is maintained only at great expense. Two iron structures have been washed out during the last few years, and at present the stream is forded during the greater part of the year, no travel from one side to the other being possible when the water is high. Red River is forded at different points in the same manner, greater stability being given to the dangerous quicksands of both rivers by the building and frequent renewal of straw roads across them.

The city of Vernon affords a limited market for such general farm produce, vegetables, etc., as is offered, while the more staple and largely grown products, cotton, cereals, beef, etc., reach the Eastern and Northern markets through Fort Worth, 163 miles distant by rail.

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SOIL SURVEY OF THE TOLEDO AREA, OHIO.

By WILLIAM G. SMITH.

LOCATION AND BOUNDARIES OF THE AREA.

The area surveyed comprises about 403 square miles, and includes parts of the counties of Lucas, Wood, and Ottawa, in Ohio, and of Monroe, in Michigan. The parts of the counties included are

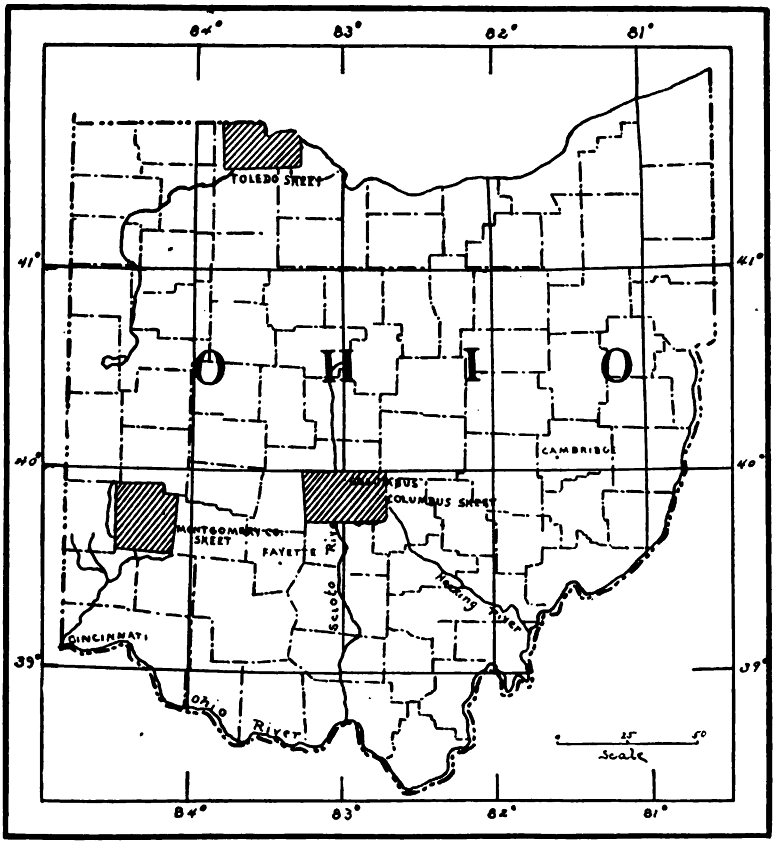

FIG. 10.—Sketch map showing areas surveyed in Ohio.

approximately, the eastern half of Lucas, the northern fourth of Wood, the western third of Ottawa, and about 20 square miles of the southern edge of Monroe. The area is rectangular in form, with a

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north and south width of about 17 miles and a length east and west of about 25 miles. The area lies between north parallels 41° 30′ and 41° 45′ and meridians 83° 15′ and 83° 45′ west from Greenwich. (See fig. 10.)

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The region in which is situated the area covered by the present survey was explored by French missionaries as early 1673, being claimed by France as a result of this exploration. Following the first entrance of the whites into what was a rich possession and a stronghold of the Indians there is a century and a half, during which the sovereignty of the territory passed from France to England, and from England to the United States, and the actual possession of the land from the Indian cultivator to the early pioneers from New England and the other States to the east. Each of these changes was the result of more or less sanguinary struggles. Even after the close of the Revolutionary war, until as late as 1795, England still occupied fortifications at the foot of the rapids on the Maumee River, near the site of the present town of Maumee, making more difficult by her presence the overthrow of the Indians.

General Wayne, in the battle of Fallen Timber, 1794, broke the Indian power and the rich valley of the Maumee was opened to settlement by the whites. Pioneers from New England, Pennsylvania, and Virginia were the first to come. They first located, within the area surveyed, in the vicinity of Maumee, laid out as a village in 1817. They brought their cattle, implements, and methods with them, but because of the distance to markets and the lack of communication the early agriculture was almost as primitive as that of the Indians, and was supplemented by hunting and fishing.

In these early days it was useless to produce except for home consumption, and prices of all commodities were ridiculously low. Burkett, in his History of Ohio Agriculture, gives the prices of agricultural products between 1800 and 1820. The price of wheat fell as low as 25 cents a bushel; corn brought 12 to 15 cents; oats, 10 cents; potatoes, 10 to 12 cents; while the price of a good cow was only $6 or $8, and of a horse from $24 to $40.

If there is one thing connected with the agricultural development of the area brought out in the first half century of growth more clearly than another it is the fact of its utter dependence upon means of communication. With each improvement in the roads, the extension of the national turnpike, the building of canals, and later the laying of the railroads the industry is seen to receive new impetus. Thus during the period from 1826 to 1836, marked by the extension of the national road from Cumberland, Md., to Wheeling, W. Va., and then to Columbus, Ohio, there was a large increase in the rate of immigration, the settlers taking up 80 to 160 acre tracts by purchase from the

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Government. The completion of the Erie Canal to Buffalo, giving water connection with Albany and the East, and of the Wabash and Erie from Cincinnati to Toledo, were also very effective factors in increasing the prices of farm products and stimulating production.

The agriculture of the area has passed through many different phases. At one time the growing of grain for shipment has been the most prominent, at another the fattening of cattle for market, at another dairying, especially as connected with the manufacture of butter and cheese. As early as 1803—in the early part of which year Ohio was admitted to the Union as a State—it was known as a cattle-raising section, and the interest in all forms of animal industry has always been keen. As a result many notable improvements in live stock have been made in the State, in some of which the area surveyed has assisted more or less directly.

Dairying, which is now the paramount interest of the area, has always held a place in the husbandry from the days of the first settlers who led their cows in from far-away New England. The earliest dairying, in a sense comparable to the industry as existing to-day, probably began about 1848, although home-made cheese was sold in Southern markets as early as 1820, bringing 25 or 30 cents per pound. It is only within the last decade that the highest stage of the industry has been reached. Now finely equipped cooperative factories dot the area, while large herds of high-bred dairy cattle are seen on every hand.

The sheep industry has also played an important part in the development of the area. At present the sheep raised are mainly mutton breeds, usually Shropshire, Southdown, and Cotswold grades. In 1860 fully 90 per cent of the sheep were of the fine-wooled Merino breed, first introduced into Ohio in 1801. The change from a wool to a mutton sheep began about 1872, and is due to low prices of wool prevailing at and since that time. The Merino sheep were largely sold to Western ranchers.

Many hogs are raised in the area. These are usually well bred and of Poland China or Chester White blood. The former breed was originated in Ohio.

The area has had its periods of depression, perhaps the greatest and most persistent of which has been the result of competition with the newer West, but it seems at present as if this danger had passed, and that a permanent readjustment between this area and the region of which it is a part and the country east and west had been reached. At least the agricultural industries prosper, and the agriculturists as a rule are contented.

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CLIMATE.

The following table, compiled from records of the Weather Bureau, gives the normal monthly and annual temperature and precipitation at three stations situated in or near the area surveyed:

Normal monthly and annual temperature and precipitation.

Month.	Temperature.			Precipitation.		
	Toledo.	Napoleon.	Rocky-ridge.	Toledo.	Napoleon.	Rocky-ridge.
	° F.	° F.	° F.	Inches.	Inches.	Inches.
January	25.7	25.7	25.2	1.97	2.19	2.40
February	26.9	24.7	26.8	2.07	1.62	1.53
March	35.8	37.9	35.8	2.20	3.06	2.84
April	48.2	48.9	49.5	2.22	2.82	2.56
May	59.2	61.2	62.2	3.34	3.16	2.48
June	69.1	70.7	70.1	3.13	2.72	2.64
July	72.5	73.0	72.3	3.17	3.76	2.99
August	71.4	70.8	72.2	2.63	1.46	2.35
September	64.0	64.5	66.4	2.28	2.41	2.95
October	53.1	51.6	53.3	2.27	1.97	2.01
November	39.6	38.6	40.4	2.80	2.95	3.96
December	29.5	30.7	30.5	2.28	2.73	2.56
Year	49.9	49.8	50.4	30.36	30.85	31.27

The figures show little difference in the records of these stations, and it is safe to conclude that conditions are comparatively uniform throughout the area, excepting the probability—no records are available to substantiate it definitely—that the rainfall is somewhat heavier and that there is greater immunity from frosts in the vicinity of the lake.

The area surveyed is situated outside of the usual path of the general storm centers, which almost invariably pass to the north or south. For this reason destructive wind storms are less frequent here, and the rainfall is not quite as heavy as in the northern and southern part of the State.

From one-third to one-half the rainfall in each of the summer months comes in one rainfall, the remainder in scattered showers of from 1 to one-half inch or less. Soil moisture experiments have shown that one-half inch or less of rainfall does not moisten the soil sufficiently to benefit crops, but that on the other hand it may even cause the drying of the soil by putting the surface in a condition which favors the rapid upward capillary movement of the ground water, resulting in a greater loss of the reserve soil water by evaporation than would have taken place had no shower fallen. It is interesting to note that the greater part of the precipitation occurs in a manner that favors the absorption of a large part of it by the soil and its conservation for crop uses. These rains are usually sufficient for the heavier soils, but sometimes the lighter, sandier soils suffer from drought toward the

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latter part of the season. Usually there is moisture enough to ripen fruits and the small grains and corn, but sometimes the soil is too dry for the proper germination of the fall-seeded grain.

The lowest recorded temperature is -16° F. and the highest 99° F. The usual range in temperature for winter is from zero to about 50° F., and for summer from 55° F. to 95° F. The annual relative humidity averages 70.8 per cent, the winter average being 75 per cent and the summer average 69 per cent. A relative humidity as low as 18 per cent has been recorded, but the minimum is normally about 40 per cent. July and August are the hottest months. The winter season covers the months of December, January, and February, during which the soil is frozen to the depth of from 4 to 8 inches and ice from 6 inches to 1 foot in thickness forms on the lake and streams. The snowfall is usually light in the early winter, while by February the weather is so far moderated that snow does not remain on the ground long at a time. The lack of snow covering is sometimes damaging to winter grain.

Injury from frosts occur here, but not to the extent reported elsewhere. The earliest killing frost in fall usually occurs the first week in October, and the last in spring during April, though there is on record such a frost occurring June 6. Usually the danger of killing frosts in spring is passed by the middle of April.

The percentage of sunshine during the winter and early spring ranges from 30 to 50 per cent, while during the summer months it ranges from 65 to 70 per cent.

PHYSIOGRAPHY AND GEOLOGY.

The area surveyed is a rather level plain, lying from 580 to 700 feet above sea level. It is intersected by many narrow streams, the largest of which is the Maumee River. The latter has eroded its channel in places to a depth of possibly 60 feet, while the smaller streams have cut their courses from 10 to 40 feet below the general level of the plain.

The sides of the stream valleys are usually abrupt and not far removed from the present stream beds. Narrow but quite well defined first and second terraces, lying from 5 to 20 feet above the water level, occur along the Maumee River, and here and there along the smaller streams.

The area of clay soil which occupies largely the eastern part of the area surveyed and the area lying adjacent to and west of the Maumee River are more regular and more level than the lighter, sandier soils along the Maumee River. The surface there is undulating, the ridges ranging from 5 to 20 feet in height. Sometimes these undulations are fashioned into quite prominent knolls and ridges, and sometimes they are entirely absent, giving place to extensive low-lying areas of

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sand. Throughout the area occasional swampy depressions occur, but these are rapidly being added to the cultivated area through reclamation by drainage, and so are losing their importance as a physiographic feature.

Geologically the area consists of a sheet of glacial material, somewhat modified, having a thickness ranging from 10 to 180 feet, and resting on a limestone formation. A general section of this material beginning at the bottom, shows the following stratification:

1. Bowlder clay, laid down during the glacial phase of the Glacial epoch, consisting of moraines and other deposits of clay mixed with bowlders.

2. Erie clay, which is a mottled bluish to grayish clay laid down during the iceberg phase of the Glacial epoch, during which time the greater part of the area was submerged to a depth of about 180 feet.

3. The lacustrine clays and beach sands, generally yellowish in color, which were laid down at the close of the iceberg period.

The Erie and lacustrine clays have weathered into a friable clay loam, which forms the basis of the extensive and important soil type described in this report as Miami black clay loam. The lacustrine clays are well adapted to brick and tile making, for which purpose they are extensively used. The lacustrine sands and mixtures of sands and clays form the basis of the two soil types described respectively as the Miami sand and the Miami sandy loam. No very pronounced exposures of bowlder clay were found in the area, and consequently this material does not figure to a great extent in the formation of any of the soil types.

The underlying hydraulic and carboniferous limestone crops out as narrow ridges and knobs in the northwestern and southern parts of the area—notably west and northeast of Sylvania and near Rockyridge. Usually the soil in the vicinity of the outcrops is stony, and such areas are indicated on the soil map by symbol. Where convenient to the surface the limestone is quarried for road ballast and building purposes and for the manufacture of lime. Owing to the presence of silica and magnesia some of the rock is unfit for lime burning, nor is it good for building purposes, because of its rapid crumbling upon exposure to the weather. In places this limestone bed is 300 feet thick.

Below the limestone is a brown shale, and below this occurs an oil-bearing stratum of sand which lies at a depth of from 800 to 1,200 feet or more below the surface. The economic importance of this oil-bearing stratum, which seems to underlie a large part of the area, is too well known to need more than a mere mention. Probably 400 wells are sunk into this sand, and others are constantly being driven.

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SOILS.

Five soil types occur in the Toledo area, all of which have been found in earlier surveys—the Miami black clay loam, Miami clay loam, Miami loam, Miami sand, and Miami sandy loam. The following table gives the extent of the several types in the Toledo area:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami black clay loam	165,056	63.95	Miami loam	5,504	2.13
Miami sand	36,672	14.21	Total	258,112	....
Miami sandy loam	20,352	11.83			
Miami clay loam	20,352	7.88			

MIAMI BLACK CLAY LOAM.

The Miami black clay loam is one of the most extensive soils of the area. It consists of from 4 to 8 inches of a friable dark-colored clay loam, underlain by a mottled yellow clay. Nearly the whole of the area east of the Maumee River consists of Miami black clay loam, while about one-third of the area west of the river is also of this type, making in all about 258 square miles, or nearly 64 per cent of the area surveyed. The surface is an almost level plain, varied only by narrow stream valleys and slight undulations rising from a few inches to 3 or 4 feet above the general level. In the depressions the soil is stained a darker color, and the color extends to a greater depth, because of the swampy conditions that once prevailed there. In such situations, also, the texture inclines more toward a loam, though the admixture of sand is not generally sufficient to warrant the establishing of a separate type. The amount of organic matter also varies considerably, being greatest in the areas more recently under water, and but recently converted to the use of agriculture by thorough drainage. This organic matter has been derived from the decay of the rank aquatic vegetation and the dropping foliage of the hard-wood forests that formerly throve in these more or less swampy spots.

The Miami black clay loam, no matter what the variation, must be thoroughly drained before it will admit of profitable cultivation. Large open ditches from 6 to 8 feet deep are dug along the roads or natural drainage depressions. These lead into some of the many streams that intersect the area, and serve as outlets for the network of tile drains running through the fields. Nearly the whole of this type is thus ditched and tiled.

The Miami black clay loam is derived from the weathering of glacial clay—a modified glacial drift material—under more or less swampy conditions, during which process often large amounts of vegetable remains were thoroughly mingled with the mineral particles. The

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color and fertility of this soil type is due in large part to this organic matter.

The range of moisture conditions under which this soil may betilled is remarkably wide for a clay soil. The surface, from 4 to 8 inches, seems to be made up of granular aggregations of clay, giving to the soil a loamy character that is not apparently warranted by its texture, as shown in mechanical analysis. In general the soil scours well on the moldboard and implements under normal moisture conditions. The subsoil is quite sticky and impervious to water, but upon thorough drainage it, too, becomes more friable. When turned up by the plow and exposed to weathering for some time, it crumbles into cubical aggregations about the size of buckshot, suggesting the "buckshot" clays of the Mississippi River alluvium. The large percentage of lime, together with the organic matter in the soil, probably helps to produce its unusually friable texture, as compared with other soils of high clay content.

This is the typical corn and grass land of the area, and it is used for wheat, though this and other small grain crops are apt to lodge where the soil is blackest and richest. (See Pl. XXII.) It is also well adapted to raising beef cattle and dairying. Considerable truck is grown; and of such crops onions are perhaps the leading product, thriving particularly well on the heavier darker colored areas of the soil. The yield of wheat ranges from 15 to 25 bushels per acre. Oats yield from 30 to 60 bushels per acre, and corn gives from 40 to 140 bushels, with an average of possibly 55 bushels per acre. Large yields of potatoes are secured, ranging between 100 and 500 bushels per acre, but the quality of the product of this soil is said to be much inferior to that of the lighter soils. The potatoes are apt to be watery and to rot more readily than those grown on the sandy soils. Some sugar beets are grown. Peaches and small fruits, such as currants, raspberries, and strawberries, seem to thrive on this type. Plums and apples also seem to do well, but not quite as well as peaches. The areas of heavier soil, where the content of organic matter is highest, would doubtless prove excellent for celery.

The size of the farms on the Miami black clay loam ranges from 40 to 140 acres, and the fields, fences, and farm buildings generally present a tidy appearance, indicative of thrift and prosperity. Almost all the type is under improvement of some kind, what is not tilled usually supporting groves of maple, oak, and elm. Such reserves are usually husbanded with a view to maintaining the supply of forest products from year to year.

The following table gives the texture of the soil and subsoil of this type, as determined by a series of mechanical analyses of typical samples secured in different parts of the area:

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Mechanical analyses of Miami black clay loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7149	4 miles SE. of Perrysburg.	Dark clay loam, 0 to 8 inches.	8.03	0.64	2.64	3.54	14.68	12.44	36.26	29.04
7153	2 miles W. of Yondota.	Dark clay loam, 0 to 10 inches.	5.14	.24	2.76	2.46	6.60	6.00	47.10	34.54
7150	Subsoil of 7149......	Mottled bluish-yellow clay, 8 to 36 inches.	1.55	.68	2.70	2.80	8.96	9.90	35.64	39.18
7154	Subsoil of 7153......	Mottled yellow clay, 10 to 36 inches.	.72	.14	.64	.64	2.38	5.44	49.70	41.08
7152	½ mile N. of Bono ..	Mottled yellow clay, 12 to 36 inches.	1.29	.04	.48	.30	1.08	4.06	37.98	55.12

MIAMI CLAY LOAM.

The Miami clay loam consists of from 6 to 10 inches of light-yellow loam, underlain by a mottled-yellow clay. The lighter, friable texture of the top soil is due both to the effects of weathering and to the leaching away of the finer clay particles. There is some variation in texture of the soil, which is heavier in the flatter areas where drainage is less effective.

The area of Miami clay loam found in the present survey is about 8 per cent of the total area surveyed. In the Montgomery County and Columbus areas, also in this State, this is the most extensive soil type, forming between 70 and 80 per cent of the land surface. In the Toledo area the soil occurs as knolls and ridges in the Miami black clay loam areas and also in well-drained places bordering the Maumee River and the smaller streams.

The surface of the Miami clay loam is sometimes flat, but usually it is sufficiently rolling to be naturally well drained. The type is derived through the weathering of the yellow glacial clay, which is believed to have been laid down at the close of the lake stage of glaciation. The subsoil probably represents approximately the original character of the clay, and the top soil was at first identical in texture with this. The differences existing between soil and subsoil as found to-day are the result of chemical and mechanical changes, the addition of some organic matter, and the removal of some of the original constituents by the leaching and washing effects of rain water.

This soil is well adapted to general farm crops, especially to corn, wheat, oats, and the grasses. It also makes good pasture land, and is therefore a good soil for dairying. Fruit can be successfully pro-

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duced on this type. The texture of the soil is somewhat heavy and sticky, and cultivation is often difficult, but this is fully compensated for by the fact that with proper management a higher degree of fertility can be maintained than is possible in soils of lighter and more open texture.

The following table shows the texture of this soil type:

Mechanical analyses of Miami clay loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6542	5 miles SW. of Toledo.	Friable clay loam, 0 to 8 inches.	1.99	0.13	1.65	9.05	17.30	5.29	38.20	26.50
7163	3 miles N. of Stonyridge.	Dark clay loam, 0 to 8 inches.	5.84	.50	2.78	2.78	9.76	10.24	46.56	26.76
7161	3¼ miles NE. of Maumee.	Dark-yellow loam, 0 to 10 inches.	2.33	.24	1.10	1.10	4.00	7.62	52.42	32.62
6543	Subsoil of 6542......	Mottled yellow clay, 8 to 30 inches.	.55	.00	1.39	6.92	14.12	5.99	42.20	29.58
7164	Subsoil of 7163......	Yellow clay, 8 to 36 inches.	.84	.74	2.70	2.14	7.60	9.20	42.06	34.82
7162	Subsoil of 7161......	Mottled yellow clay, 10 to 36 inches.	.93	Tr.	.78	.74	2.60	4.90	44.16	45.48

MIAMI SANDY LOAM.

The Miami sandy loam consists of from 8 to 20 inches of sandy loam underlain by a mottled yellow clay that is in some cases very sticky and free from sand and in other cases quite sandy. In texture it is intermediate between the heavy clay and yellow beach sands, which figure respectively in the Miami black clay loam and the Miami sand, between areas of which it is usually found. The local variations are often quite wide. Adjacent to the Miami black clay loam the soil consists of about 8 inches of fine sandy loam, often dark in color, which grades rapidly into a heavy mottled clay subsoil, while bordering the Miami sand it consists of from 20 to 30 inches of yellow sandy soil, medium to coarse in texture, passing sometimes into a rather loose sandy clay substratum and sometimes into a stiff mottled clay.

The Miami sandy loam generally has a higher elevation than the Miami black clay loam or the Miami clay loam. The surface, which is rolling, is somewhat rougher than that of the latter types. The elevation ranges from 600 to 700 feet above the sea, usually being about 620 feet. The undulations rise in easy slopes from 5 to 10 feet above the general level. The soil on the knolls and ridges is usually lighter in color and sandier in texture than the soil in the depressions.

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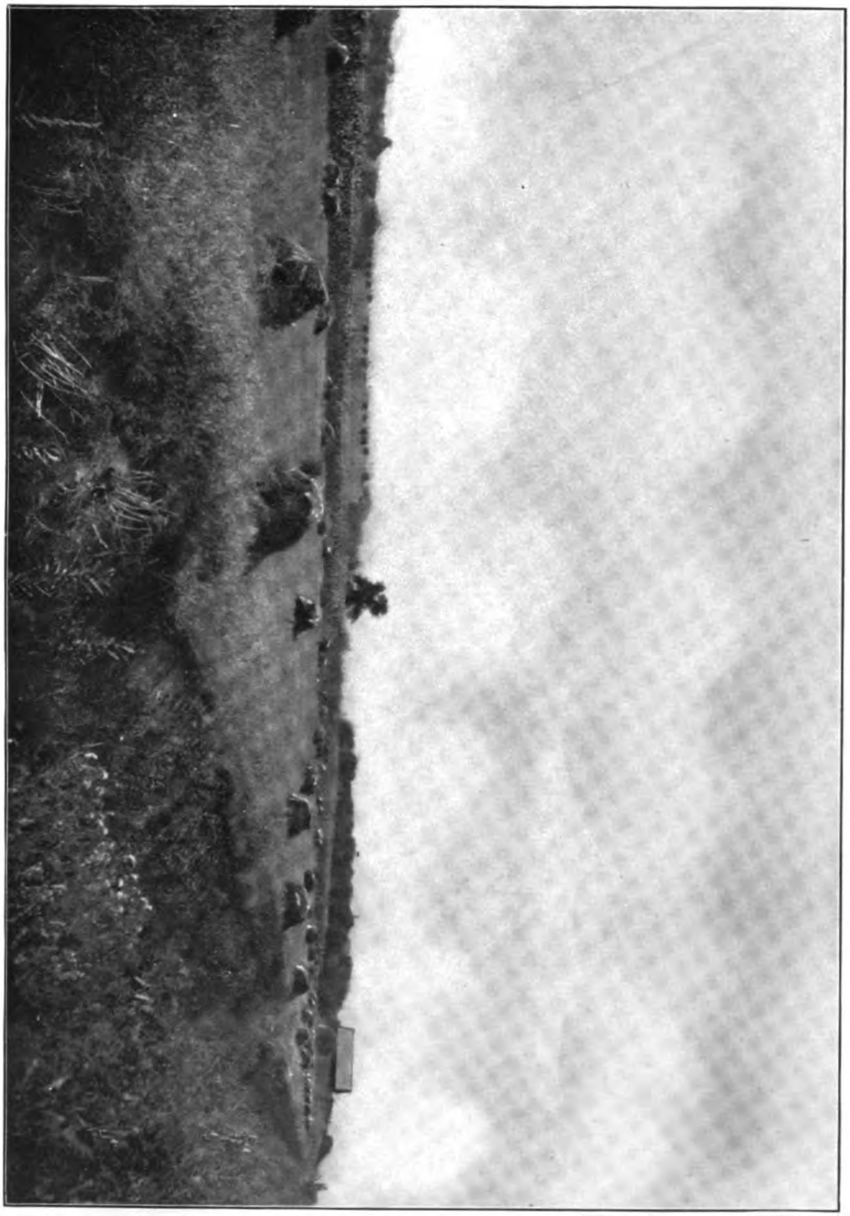

WHEAT AND CORNFIELD ON THE MIAMI BLACK CLAY LOAM, SHOWING A DRAINAGE DITCH, TOLEDO AREA, OHIO.

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This type possesses fair natural drainage, because of its undulating surface and the presence of many small streams and draws. Artificial drainage, however, is resorted to in order to insure good tilth for the depressions.

This soil is derived from the weathering of the glacial clay and beach sand. The glacial clay, which is mottled in appearance, enters principally into the subsoil, while a mixture of the beach sand and clay forms the surface soil of the type.

Because of its sandy nature, this soil plows readily and is tillable under a wide range of moisture conditions. Grain, grass, corn, and truck are grown with success, the type as a whole being best adapted to corn and truck. Owing to prolonged droughts that not infrequently occur in this type, the grass and small grains suffer. Especially in a dry, open winter, wheat is often injured to even a greater extent than it is on the heavier soil. The yield of wheat ranges from 10 to 25 bushels, and averages about 18 bushels per acre. Oats range from 20 to 50 bushels per acre and corn from 35 to 70 bushels per acre. Strawberries and other small fruits, apples, plums, and peaches also do quite well. The quality of the crops grown is generally quite good. The potatoes especially are superior to those produced on the heavier soils, being more mealy and of better keeping quality.

The farms range in size about the same as those noted on the Miami clay loam, namely, from 40 to 140 acres, and by the general appearance of the fields, fences, and buildings the thrift and prosperity of the farmers is not less than on that type.

The following table gives mechanical analyses of this soil:

Mechanical analyses of Miami sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7145	2¼ miles W. of Toledo.	Dark sandy loam, 0 to 12 inches.	2.31	0.10	0.72	3.10	28.38	18.20	40.98	8.40
7147	6 miles N. of Maumee.	Black sandy loam, 0 to 8 inches.	4.89	.22	.66	2.18	34.16	25.74	26.98	10.06
7146	Subsoil of 7145	Sandy clay, 12 to 36 inches.	.66	.02	.60	1.18	10.90	15.98	58.50	12.56
7148	Subsoil of 7147	Dark bluish clay, 8 to 36 inches.	1.08	.44	1.26	2.80	33.16	22.90	25.64	13.76

MIAMI SAND.

The Miami sand consists of 3 feet of yellowish sand resting on a substratum of the same texture with a thickness of from 8 to 20 or more

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feet. The sand is of medium grade and contains very little clay, except sometimes in the depressions or in areas adjoining some of the heavier soils. On the whole the soil is characterized by a loose, sandy texture. It is easily tilled and is workable in all kinds of weather. Occasionally at from 3 to 8 feet below the surface the sand rests on a substratum of clean white quicksand. Over such areas fruit trees or other plants that root deeply do not seem to grow well.

The Miami sand is found principally in the western part of the area. It extends in an area 4 or 5 miles wide parallel to the Maumee River, from which it is about 3 miles distant. This type ranges in elevation from 600 to 700 feet above the level of the sea, its average elevation being slightly greater than that of the other types. Its surface is also marked by greater depressions and elevations, consisting of knolls and ridges from 10 to 30 feet above the general level, with expanses of lowland between them. In some cases these flat areas are quite extensive, possessing occasionally a swampy character until artificially drained. Owing to the undulations, the open texture of the soil, and the presence of streams, this soil is in the main naturally well drained. The flatter areas are frequently drained, but artificial drainage has not been employed to so great an extent as in the other soil types, and there are large areas of swampy lands yet in virgin forest. Such areas when drained are the most productive of the type because of the large amount of organic matter mixed with the sand.

The Miami sand is derived from the beach sand laid down at the close of the iceberg stage of the Glacial epoch. The sand is thought to mark an ancient shore line of Lake Erie.

Grass, corn, wheat, truck, and fruit are grown on this soil. The quality of these is good and in some cases better than the produce grown on the other soils of the area, but the yield is usually from 15 to 30 per cent less, and crops sometimes are cut short or fail because of the susceptibility of this soil to drought. The yield of wheat ranges from 10 to 20 bushels per acre, and of corn from 20 to 45 bushels per acre. Grass and winter grain do only moderately well, being subject to winter killing if the season be open and dry. This soil yields from 75 to 120 bushels per acre of an excellent quality of potatoes. The Miami sand is the typical truck soil of the area. Of the fruits, apples, plums, and strawberries seem best adapted to it.

The very deep sandy areas are not much tilled, but are left in their native growth of scrub oak. Such lands are called "oak openings." A great quantity of stable manure would be required to make these areas productive. Quite a number of thrifty-looking farms are found on the lower-lying and heavier phases of this type, but on the other lands the improvements are less substantial and not in as good repair. The lighter soil brings from $5 to $20 per acre, while the heavier soil, similarly situated, brings from $30 to $100 per acre.

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The following table of mechanical analyses shows the texture of soil and subsoil of this type:

Mechanical analyses of Miami sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7143	3 miles W. of Toledo.	Dark sand, 0 to 12 inches.	2.53	0.20	1.64	7.08	37.66	33.54	15.60	2.54
7141	3 miles S. of Sylvania.	Dark-yellow sandy soil, 0 to 8 inches.	3.38	.64	8.50	24.74	51.34	5.50	5.64	3.46
6544	5 miles W. of Toledo.	Brown sand, 0 to 36 inches.	.93	.10	3.74	20.15	51.00	15.92	5.45	3.59
7142	Subsoil of 7141	Yellow sand, 8 to 36 inches.	.70	.50	9.18	26.74	53.70	4.62	1.70	2.38
7144	Subsoil of 7143	Yellow sand, 12 to 36 inches.	.57	.00	1.36	6.20	37.98	37.60	11.90	4.78

MIAMI LOAM.

The Miami loam is a black loam with an average depth of 12 inches, underlain by a subsoil slightly heavier in texture. There are some local variations in character, the soil being slightly more sandy on the elevations and more clayey in the depressions. Occasionally small areas contain rounded gravel and more angular rock fragments. This soil type occupies the stream bottoms. Along the Maumee River it is found on two distinct terraces, the lower between 2 and 8 feet and the higher between 10 and 20 feet above water level. Along the other streams the terraces are less distinct. They are usually quite narrow, the widest, occurring along the Maumee River, being about one-third of a mile wide.

The surface of this soil is generally flat, but with sufficient undulation to give good natural drainage. Artificial drainage is rarely resorted to.

Geologically this type is the youngest in the area. It is derived from the glacial drift, modified by stream action occurring during its transportation and redeposition in the formation of the terraces.

The Miami loam is one of the more fertile soils of the area. Some of the fields, tilled for more than half a century and only moderately manured, still produce abundantly. Corn and other grains, truck, and fruit thrive on this soil, the last especially on the higher terraces. Corn yields from 40 to 100 bushels per acre, with the average production probably about 75 bushels, and wheat from 20 to 35 bushels per acre. The fields usually appear well kept and productive. Except on

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the higher terrace, farm buildings are not found on this soil. They are usually situated on the adjacent higher and drier uplands.

The following table of mechanical analyses of typical samples of the Miami loam shows the texture of this soil:

Mechanical analyses of Miami loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7157	2¼ miles W. of Toledo	Dark sandy loam, 0 to 10 inches.	2.91	Tr.	0.64	1.24	21.64	27.14	39.92	9.28
7159	Perrysburg	Dark-brown loam, 0 to 12 inches.	4.95	0.60	3.50	5.08	20.64	18.96	36.24	15.06
7158	Subsoil of 7157	Dark-brown clay loam, 10 to 36 inches.	1.56	Tr.	.64	1.06	17.18	27.64	41.26	12.24
7160	Subsoil of 7159	Reddish-brown loam, 12 to 36 inches.	1.90	.64	6.22	8.24	22.60	19.20	27.06	15.78

DRAINAGE.

Ohio has a comprehensive drainage law. It is incorporated in the organic law of the State, and has been held constitutional by the supreme court on the ground that drainage promotes the "public health, convenience, and welfare." The law permits the construction of a drain through property not especially needing drainage, and against the wishes of the owner, in order to permit the drainage of lands beyond which may be in just need of drainage. Provision is made for the payment of damages to the owners of lands not benefited and for the assessment of the cost of construction against lands benefited. A drain is procured on the petition of citizens, secured by bond sufficient to pay preliminary expenses, which is addressed to the township officer, in case the drain lies wholly within the township, or to the county commissioners if it pass through two or more townships. The survey and construction of the drain and the prosecution and defense of any legal issues involved are all attended to by the State.

The drains usually consist of an open ditch 2 feet wide at the bottom with sides sloping at an angle of 40 degrees. The average depth is estimated as about 4 feet, the depth ranging from 3 feet to 8 or 10 feet The average cost of excavation is about 7 cents per cubic yard of earth moved and the cost per mile on this basis amounts to about $450.

The drains are dug by contractors, or by the farmers themselves in

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lieu of payment of assessment. The owner of land through which the drain passes is always given the opportunity to dig the ditch himself if he so desires. The fact that many farmers take advantage of this opportunity is the reason for the small rate per cubic yard for excavation.

The shallower ditches, those not exceeding 2 or 3 feet in depth, are sometimes dug with ditching plows, which have been found to be economical. A ditch dredging machine, the invention of a Toledo man, is used for digging tile drains. It is said to save one-fifth the expense of hand work.

The large open ditches in the flat black clay (Miami black clay loam) areas usually run alongside the public roads. As the roads within the limit of this survey generally run on section lines, and most of them have drainage ditches by their sides, some idea of the extent of these public drains may be formed. Into these open ditches the tile drains from the adjacent fields empty. In the Miami black clay loam areas the tile drains are placed at intervals of about 100 feet. The tiles used in these lateral drains are usually 3 or 4 inches in diameter, but when branches or laterals are extended from these outlet drains, the size of the tile in the main drain varies from 5 to 8 inches in diameter.

The cost of tile, which is made at local factories from the mottled clay underlying the greater part of the area,[a] is from 20 to 50 cents per rod for 3 to 6 inch tile, while the cost of laying the tile is about as much more, making the total cost of the tile laid in the land range from 40 cents to $1 per rod. The tile is laid at depths varying from 18 to 30 inches. In all the drains and ditches the fall is about one-tenth of a foot per 100 feet. The soil in the area most in need of draining is the Miami black clay loam, while all of the types are benefited to a greater or less extent. Before drainage but very little of the Miami black clay loam could be cultivated because of the water that stood over it nearly the whole summer through. This type comprises much of the area referred to as the "Black Swamp" in some of the earlier agricultural reports of the State. Since it has been drained nearly all of it is under cultivation and its value has risen until the asking price ranges between $60 and $100 per acre. It is rarely that tax sales of this soil occur. The Miami clay loam and Miami sandy loam are also tiled to a considerable extent, especially where the areas lie in depressions, and much better crops are grown in such areas. It is estimated that the increase in yield and improvement in quality due to drainage of the soils has resulted in an increase of from 10 to 30 per cent in the value of the crops, while the Miami black clay loam, producing practically nothing

[a] For further discussion of the manufacture of tile, as well as some notes on the history of tiling and benefits arising from tile draining, see Columbus area this report, p. 418.

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until drained, is now the most fertile and most productive soil in the area. (See Pls. XXI and XXIII.) The black, sandy, and sometimes swampy depressions in the Miami sand are also drained with much benefit to crops. The Miami loam, occurring as it does along the streams as terraces, as has been said, has good natural drainage and is rarely drained artificially.

Experience in drainage in this area shows the following benefits arising from thoroughly tiling and ditching the soils: The quicker warming of the soil in the spring, the better and more uniform distribution of soil water at all times, as well as the carrying off of the excess of water, the better yield and quality of crops, the greater certainty of the crops, the increased value of the land, and the better health of the community.

AGRICULTURAL CONDITIONS.

The farmers of the Toledo area are prosperous. During the last four years there has been a constant improvement in the conditions. Mortgages are being reduced, and permanent improvements—new houses, barns, and fences—are being made throughout the area.

The greater number of the farms in the Toledo area are tilled by the owners, but there are also a large number rented. According to the Twelfth Census of the United States, 72.5 of the Ohio farmers own their farms, 8.7 pay a money rental, and 18.8 farm on shares. These figures are thought to represent with fair accuracy the condition in the Toledo area. Some of the rented farms of the area are owned by well-to-do, retired farmers, while others are the property of bankers and money lenders who have come into possession through mortgage foreclosure. Such foreclosures were all too common a few years ago, during the period of low prices and general commercial depression, but with the better times of the last four or five years sales to satisfy mortgages have been comparatively rare.

The size of the farms ranges from 20 acres, or even less near the towns and cities, to 150 acres farther away—30, 40, 50, and 80 acre farms being the sizes more commonly met with in this area. The valuation per acre ranges from $200 near Toledo and the smaller towns down to $30 in places more removed. Some land is held at as low as $8 per acre, but such cases are the exception and the result of both poverty of soil and disadvantages of location and topography.

The houses are usually plain, frame buildings worth from $500 to $3,000, with an average value ranging perhaps between $1,000 and $1,500. The barns have about the same range in value, with the average value possibly a little less. The old worm rail fences are gradually giving way to wire fences of different kinds.

The condition of the area with respect to labor is fair, but at times, especially during the harvest season, labor is scarce. The hired hands are made up in part of farmers' sons and in part of transients obtained

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in the cities and towns. Wages average from $16 to $18 per month with board. Day labor is paid during the rush of harvest from $1.25 to $1.75. The farm laborer is generally an intelligent man and the quality of service is above the average, taking the country at large. The farmers are largely of German, English, and Irish extraction, and the laborer, also, is usually of some one or a mixture of these nationalities.

One or two decades ago much attention was devoted to the growing of wheat and other grains for shipment. Recently this has been changed, largely to the growing of crops of this character—grain, grass, corn, etc.—for home consumption, converting them into more condensed products, such, for instance, as butter, cheese, and beef. It will be seen that all these products are of a character to give a substantial revenue without taking away from the farm much, if any, of the fertility of the soil. It is asserted by some, identified many years with the dairy business, that the farmers of this section are 20 per cent better off than they were before the dairy industry had been so generally introduced. This is not only because of the direct profit to be made in the sale of milk, butter, and cheese, but also because of the increase in the fertility of the soils managed under the dairy system. Much of the fertility lost under the earlier system of hay and grain farming has been restored on these dairy farms, and that without the aid of artificial fertilizers, which are very little used in the area, except by truck farmers. The rotation commonly practiced is corn, followed by grain, and then grass. Some have sought to eliminate grain, but have found that better results are secured by retaining it in the rotation.

The dairy industry of this area has passed through many changes in the last twenty-five years. First came the period of home dairying, when cream was gathered by the gravity system. Following this came the building of private factories and the purchase of cream from the producers; then the imitation creamery factories, under which system each farmer churned his own butter and delivered it to the factory uncolored, where it was worked over and colored in imitation of June butter. After this came the manufacture of oleomargarine and later butterine, which nearly ruined the dairy industry before it was checked by legislation. The invention of the separator and cream tester were the next steps in the evolution, and the cream-gathering system was again begun. The factories this time were erected by the manufacturers of separators as a preliminary to the sale of hand separators to the farmers, but owing to the costliness of the machines and the hard times prevailing at that time this was not as successful as it was thought it should be. The farmers gradually becoming interested in the factories as stockholders, the present cooperative system was the outcome.

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All the various systems except the first have been more or less failures as far as the manufacturer is concerned. The weak point in the present system is the difficulty of securing among many widely scattered producers the absolute cleanliness necessary to the manufacture of the best quality of butter. The carelessness of one person may taint an entire churning.

There is now a movement on foot to concentrate these small cooperative factories into large concerns so located that they might have shipped to them on fast trains the cream from farms even 100 or 200 miles distant. It is thought by some that this plan will fail, because of the greater chance of uncleanliness on the part of the producers. With the local factory system there is more likelihood that the dairyman will be personally interested in the quality of product, and he who might be lax is also under a closer scrutiny of the factory authorities, which can not but have a wholesome effect on his methods. These large factories plan to offset the effect of poor cream by renovating the butter when it is tainted; but laws are being enacted requiring renovated butter to be labeled as such, which injures its standing in the market. The present local cooperative system will probably continue. There is little doubt that the cooperative system is better for the individual welfare of a given locality, and therefore, on the whole, much more to be desired than the system of greater centralization.

In the area surveyed it is estimated that there is one dairy factory to about every 100 square miles, or one to every three townships. Some of these factories make butter exclusively; others make either butter or cheese. Butter is the more stable product in the market, the price averaging the last few years 25 cents per pound, while the price of cheese fluctuates widely, ranging from 3 to 12 cents per pound. Hence butter is made the year round, while cheese is made only a part of the year, or at such periods as good prices prevail.

Ohio has a State milk-inspection law which requires milk sold to private consumers to contain 3.25 per cent of butter fat.

Fattening cattle for beef is also a part of the husbandry of the area, but it is not as profitable as dairying, owing to the competition with the range-fed cattle of the Western plains.

While the area is distinctively a dairying section, recently there has been a considerable development in fruit growing for both the local and distant markets. There is apparently no reason why the production of fruit could not be made a more important part of the husbandry of the area. The fruits chiefly grown are the peach, grape, raspberry, and apple, and the most extensive orchards and vineyards are found near the Maumee River, Maumee Bay, and Lake Erie, where both the soils and climate seem better adapted to the industry. Farther away from these waters some fruit is grown, especially apples.

Sugar beets are grown to some extent on the Miami black clay loam

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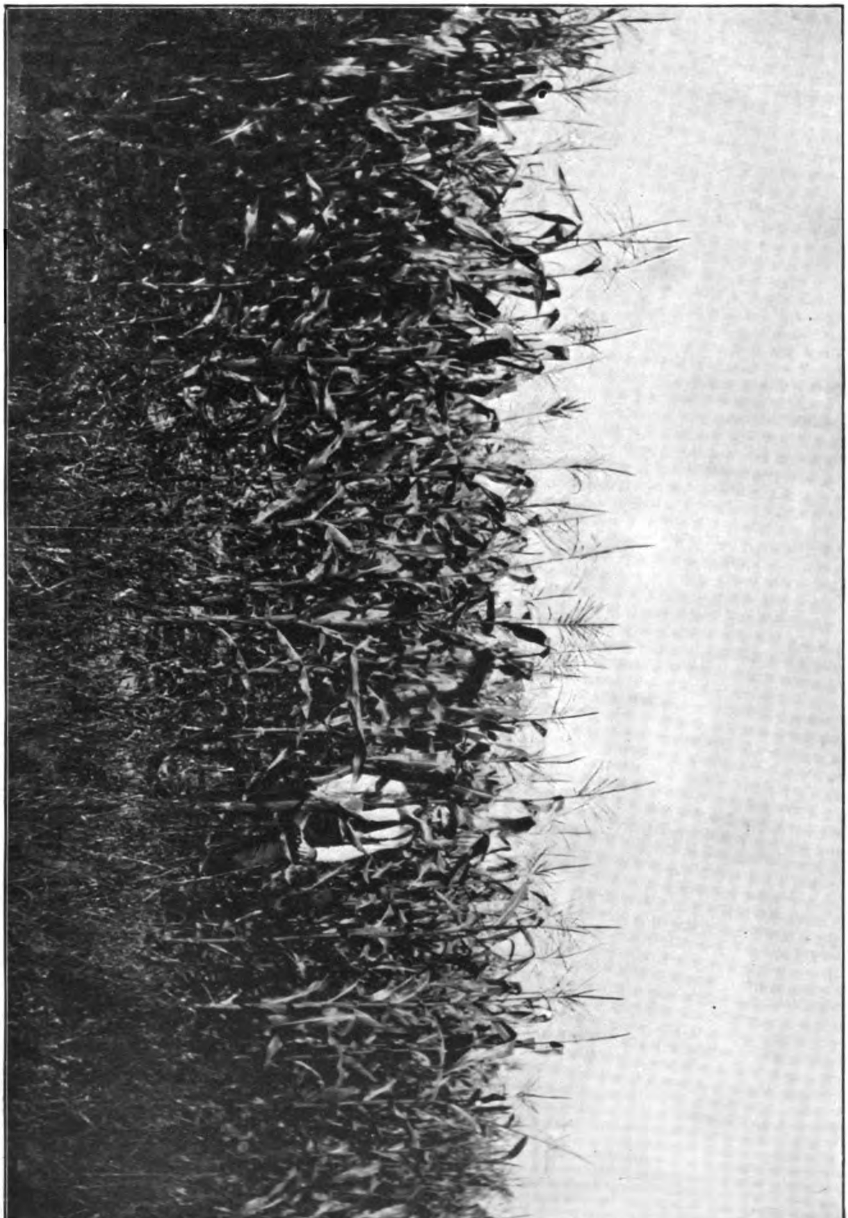

VIEW OF A CORNFIELD ON THE MIAMI BLACK CLAY LOAM, TOLEDO AREA, OHIO.

This is the typical corn land of the black prairies of the Middle West.

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FIG. 1.—GROUP OF FARM BUILDINGS ON THE MIAMI BLACK CLAY LOAM, TOLEDO AREA, OHIO.

Showing the prosperity of the country and the comforts and conveniences of farm life in the area.

FIG. 2.—SUGAR BEETS, CABBAGES, AND CORN ON THE MIAMI BLACK CLAY LOAM, TOLEDO AREA, OHIO.

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in the eastern part of the area. There are no beet sugar factories within the limits of the present survey, but there are two near it, one at Monroe, Mich., and the other at Fremont, Ohio. The price paid for sugar beets varies from $4 to $7 per ton, delivered at the factory, depending on percentage of sugar and abundance of the crop.

On the low-lying areas of Miami black clay loam near Lake Erie large quantities of onions are grown. Beds of onions may be seen there half a mile or more in length. Large quantities of potatoes and cabbage are grown there also.

The adaptability of soils to crops has already been brought out in the separate descriptions of the soil types. The matter is here repeated to emphasize the differences of the several types in crop production, and to enable a more ready comparison of their individual characteristics than is possible where statements are scattered about on different pages.

The Miami black clay loam in its natural state produced little of value except coarse marsh grasses. As it is to-day, thoroughly drained and well tilled, it is suited to the production of a variety of crops. Among these may be mentioned corn, winter grain, grass, orchard and small fruits, truck—especially onions, potatoes, and cabbage—and sugar beets. The Miami clay loam is used for about the same crops as the Miami black clay loam, but is rather better than that type for wheat and fruit.

The Miami sandy loam is also suited to the general farm crops, but is better adapted to certain of the truck crops, which its texture will suggest, and to fruit. Of the last, the apple and plum appear to give the best results. The Miami sand is still less a general farming type, though used for that purpose in places too remote from market and transportation facilities to make the growing of truck, to which industry it is best adapted, profitable.

Finally, the Miami loam, occurring as well-drained terrace and bottom lands, seems adapted, like the Miami black clay loam, to the general farm crops, fruit, and truck.

A general view of the soils of the area shows less marked differences in adaptation than might be expected from the differences in the character of the soils. In other words, there is room for a much nicer distinction in the crop value of the soils and the wider introduction of special crop interests.

A source of revenue to some of the farmers peculiar to this section lies in the oil wells. On many of the farms in the area there are from one to four or more wells in active operation. From these the farmer receives a royalty amounting to $1 or more per day, while he tills his fields as usual on the portion of the land not occupied by the oil-well operators. In the whole area there are about 400 oil wells at present in operation.

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The transportation facilities of the area are very good. Some 20 lines of railroad center at Toledo, several of them being main-line transcontinental roads. Toledo, which lies about 10 miles inland from Lake Erie, is also a point of large shipment for lake traffic, the Maumee River being navigable for the largest lake boats. There are large grain elevators, iron works, bridge works, and other manufacturing and wholesale business interests located in the city and dependent upon the low freight rates which the competition of the many lines of communication centered there promotes.

The area is also well supplied with trolley lines, some of them connecting with distant cities. These lines handle freight as well as passenger traffic, and are a great convenience to the producers of commodities for local consumption.

The wagon roads are usually well kept. Some are surfaced with clay or gravel and some are macadamized.

The city of Toledo, with its population of about 132,000, is the chief market, but a score of smaller towns also consume a considerable part of the products of the area. There is no difficulty in reaching any of the distant markets east or west.

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SOIL SURVEY OF THE COLUMBUS AREA, OHIO.

By WILLIAM G. SMITH.

LOCATION AND BOUNDARIES OF THE AREA.

The Columbus sheet covers an area of about 471 square miles. In form it is a rectangle, with its east and west dimension 27 miles long and its north and south extending 17½ miles. Columbus, the principal city, is located in the north central portion of the area. The area includes, approximately, the southern half of Franklin County, the northern one-seventh of Pickaway County, and small portions of the adjoining counties of Madison, Fairfield, and Licking. Geographically the area lies between latitude 39° 45′ and 40° north, and longitude 82° 45′ and 83° 15′ west. (See fig. 10.)

The location is an interesting one in many ways. The soils are all quite distinct as regards texture and adaptability to certain methods of farming, and the history of the development of the region contains much of general application.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

On July 13, 1787, the Congress of Confederation, assembled in New York City, enacted the famous ordinance of the Northwest Territory. Fifteen days later this Congress passed an act disposing of 5,000,000 acres of land in Ohio at about 10 cents per acre. The following year the Ohio Company, with 1,500,000 acres under its control, planted its first permanent settlement (Marietta) in Ohio at the mouth of the Muskingum River. The remainder, consisting of 3,500,000 acres, was secured by the Scioto Company. Two million acres more were granted to John Cleves Symmes between the Little and the Great Miami rivers.

Large inducements by these land companies were at once offered settlers, and soon many immigrants came into the Ohio Valley. In fact, emigration from the East to this new, rich territory became so great as to alarm the older settled region, even to the point of issuing antiemigration pamphlets in a vain attempt to check it.

As a result of the exploitations of these land companies, the existence of large areas of cheap Government land, and the enactment by Congress of military and refugee grants, the Miami Valley, the Mus-

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kingum Valley, and the Scioto Valley, in which the present soil survey is situated, soon became the home of many pioneers.

The earliest settlement in the area surveyed occurred in 1797, about which time the town of Franklinton—in 1802 incorporated as Columbus—was laid out and occupied by emigrants from Kentucky and Pennsylvania. In 1799 some other families settled on Darby Creek, near where at present stands the town of North Liberty, and others located near the mouth of Gahanna Creek. From all these places settlement gradually extended, following, naturally, the principal water courses.

The soil proved to be very productive. Large crops could be produced, plenty of grazing lands were to be had along the streams, and the fattening of cattle and hogs and the making of dairy products were all possible; but it was of no use to produce, for there was practically no market beyond the local, because of the lack of transportation facilities. The roads over the Allegheny Mountains to the east were well-nigh impassable, even if the great distance to the eastern market had not made the movement of crops impracticable. The only outlet was by flatboat down the Mississippi and Ohio rivers to New Orleans, and thence to the outside world. This means of transportation, though used, entailed much arduous labor, not to mention danger to life. The first flatboats to descend to New Orleans after the raising of the Spanish embargo were floated in 1788. They were manned by 150 armed men—armed because of the danger from attack by the Indians and outlawed whites, especially on their long march back from the market, for the return had to be made on foot. Hazardous as was this method of transportation, many entered it, and the trade grew to large proportions, continuing until after the war of 1812.

All this time a steady stream of immigrants, attracted by inducements offered by the land companies, continued to pour into the Ohio Valley, and the products of the soil began to far exceed the demand of the then available market. It became evident that some other outlet than that by way of the Ohio and Mississippi rivers was necessary to the continued growth and development of the then settled portion of Ohio. At this juncture, in 1805, George Renick, whose farm was situated about 40 miles south of Columbus, on the Scioto River, near the present site of Chillicothe, crossed the Alleghenies with 68 head of fat steers and drove them to Baltimore in good condition, selling them at a good profit. This experiment was followed by others equally successful, cattle being driven to Philadelphia and New York. Thus was opened up a new avenue of trade and a new industry, the live-stock industry, which soon led to the importation and improvement of breeds of cattle, sheep, swine, and other farm animals.

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The next important factor in the development of the now rapidly growing agricultural industry of Ohio at large and the area surveyed in particular was the extension of the national turnpike from Cumberland, Md., to Zanesville, Ohio, and later, in 1833, to Columbus. By 1836 the road had reached Indianapolis, Ind. Important also was the completion, in 1831, of the Columbus feeder of the Ohio Canal, which gave the area direct water communication with the Ohio River and Lake Erie. By 1838 the Ohio Canal connected Columbus with Cleveland, Toledo, Cincinnati, and Portsmouth. In 1850 the first railroad, extending from Columbus to Xenia, was built, and one year later a road was in operation between Columbus and Cleveland.

With each improvement in transportation the production of the staple crops and of cattle, of dairy products, and of wool kept pace, and the history of the development of this area all in the brief period of the first half of the nineteenth century is truly remarkable.

A change in condition, due to the opening of the newer West, then began to affect the Ohio farmers, just as those of the Eastern States had been affected by the competition of Ohio. Great transcontinental railroad lines were laid down, and back to the Eastern market came thousands of cattle which had been fed on the range and fattened on the millions of bushels of grain grown on these new lands. Immense crops of wheat were raised and sent to the Eastern market, reducing the price to from a third to a half of what it had been. Had it not been for the fairly good local market here the farmers would have suffered even more than they did from this competition. As it was, many became bankrupt and farms were sold at sheriffs' sales, while mainly those who rapidly adjusted their methods to fit as far as possible the new conditions continued to do fairly well.

The West, however, even with its rich soils could not continue to produce the bounteous crops with the methods employed. The continual cropping of the fields to wheat without manuring soon brought about the inevitable result of reduced production. The natural ranges also began to deteriorate. Vast areas were ruined by overstocking, by the introduction of sheep, which cropped the grass to the roots, and other improvident methods. Thus the competition became less strenuous, and matters mended in Ohio. Now the readjustment of conditions has progressed until the agriculture of the area is again on a prosperous footing.

CLIMATE.

The summer temperature is characterized by periods, one and two weeks in duration, of warm weather, when the thermometer registers between 90° and 104° F. during the day, and does not fall below 60° or 75° F. at night. When accompanied by a high humidity and slight

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wind movement the atmosphere becomes very oppressive, sickness is increased, and the fungous diseases of plants become more prevalent. These heated terms are most likely to occur during July and August, but the greater part of the summer the temperature ranges between 60° and 80° F. The normal annual temperature is 51.8°, and the normal monthly temperatures range from 29.4° F. in January to 74.9° in July.

The winter temperature generally ranges between zero and 50° F., but the mercury sometimes sinks as low as 20° F. below zero, and sometimes rises to 70° F. above zero.

The average date of the last killing frost in spring is April 20, and the average date of the first killing frost in fall October 18. The depth to which the soil freezes during winter varies from 6 inches to 20 inches or more, depending on the intensity and duration of the cold, the snow covering, and the character of the soil. The clay soils freeze to a less depth than the more open sandy and mucky soils.

The normal annual precipitation for this area is about 38 inches. In the midwinter season the precipitation takes place as snow, which usually covers the ground to a depth of from 4 to 8 inches for periods of from two to six weeks of January and February, protecting shrubbery and small grains from the severest weather. Open winters, however, are not uncommon and some damage is done, especially to winter grains and grasses.

During the fall and spring the precipitation usually occurs in rain storms of considerable duration, favorable to absorption by the soil. In the summer season, however, the precipitation comes in local showers not so favorable to absorption by the soil and sometimes so violent as to flow over the surface of the soil directly into the streams. The rainfall for the summer months ranges from about 2 to 9 inches, the normal ranging from 3 to 4 inches. The relative humidity in winter fluctuates daily from about 30 to 50 per cent, and in summer from about 40 to 65 per cent, though during the periods of excessively warm and moist weather a relative humidity of from 80 to 95 per cent is often registered. The annual average sunshine is about 45 per cent of possible sunshine. For January the average sunshine is 30 per cent, and for July it is 55 per cent. The days of continued cloudiness are limited mostly to the winter season. The prevailing winds are from the west and southwest. The winds from the east and southwest bring the rains. Cloudbursts and tornadoes are not common, but occur occasionally and are sometimes so severe as to cause loss of life and property. The table following, showing rainfall and temperature by months, is compiled from the records of the Weather Bureau station at Columbus.

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Normal monthly and annual temperature and precipitation.

Month.	Columbus.		Month.	Columbus.	
	Temperature.	Precipitation.		Temperature.	Precipitation.
	°F.	Inches.		°F.	Inches.
January	29.4	3.09	August	72.6	3.22
February	30.5	3.33	September	66.6	2.73
March	37.6	3.31	October	53.7	2.55
April	51.5	2.67	November	40.6	3.27
May	62.1	4.04	December	32.7	2.51
June	72.4	3.44	Year	51.8	38.07
July	74.9	3.91			

PHYSIOGRAPHY AND GEOLOGY.

The area surveyed consists geologically of a deposit of glacial drift varying from a few feet to over 200 feet in thickness, resting on a rock floor composed of limestone in the western border and passing toward the east through shale into sandstone.

The drift material is thought to have been deposited during a long period of time, the forepart of which was characterized by the southward movement of the vast ice sheet. The surface of the rocks over which this mass of ice passed was ground into a fine flour, which became the clay constituent of the drift. The larger rock fragments were rounded and shaped into the bowlders and gravel, also a salient feature of the drift material. Intermixed with this material of local derivation there is a considerable quantity of foreign material transported by the ice from the regions farther north. Bowlders composed of gabbro, gneiss, and granite are found which have no representatives in place in the area.

The drift varies greatly in different localities, and it is therefore difficult to construct an ideal section or to draw consistent conclusions as to the forces that operated during its deposition. In a general way the material seems to have been first laid down in strata of sand and gravel and large rounded stones, upon which was deposited later the bowlder clay. The latter material is of special interest, as it is the principal source of the soils of the area.

The forces operating in building up the drift were doubtless much modified by the irregularities of the rock floor upon which the material rests. The preglacial stream valleys and the hills and knobs all had a part in giving to the drift local variations that seem difficult to explain and which do not fit into the very general section just given. For example, instances are found where the bowlder clay is overlain or interbedded with the gravel.

It has been suggested that the stratified drift was laid down during a time when the ice retreated northward, when immense quantities of water flowed rapidly over the whole area in one vast sheet. The nicely

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stratified beds of sand and gravel often found underlying the clay certainly give color to such a theory. Later, when the water moved more slowly or possibly stood as a lake over the area, the clay and silt, together with rocks and bowlders and gravel dropped from floating ice, were deposited. The possibility of lacustrine origin of the bowlder clay was once supported by the hypothesis of a glacial dam at Cincinnati, but the existence of such a dam is now called into question through some of the later geological researches. At the close of the Glacial period the surface of the drift must have presented an almost level plain, possessing only very slight variations in the form of easy sloping knolls and ridges. This formation is shown to-day in the interstream portions of the area.

The present physiography of the region is the physiography of the ancient plain, more or less modified through erosion by the streams in building up the present drainage system.

The principal streams flowing through the area are the Scioto River, the Olentangy River, Big and Little Darby creeks, Big and Little Walnut creeks, and Alum Creek. All of these streams flow southward into the Ohio River, while their branches have a general east and west direction.

The stream valleys are not usually very extensive, the largest occurring along the Scioto River, varying from three-fourths mile to 1½ miles in width. Along the smaller streams the width is usually between one-fourth and three-fourths mile.

The sides of the stream valleys are usually quite steep, and some along the Scioto River and Darby Creek are quite high as well as steep, rising from 50 to 150 feet above the stream bed.

Two well-defined terraces usually occur along the streams. The lower, or "first bottom," as it is locally called, lies from 8 to 20 feet above the stream beds and is generally indicated by the Miami loam soil type. The higher terrace, locally called "second bottom," lies from 20 to 60 feet above the stream beds and gives rise to the important Miami gravelly loam soil type. Sometimes on a high first bottom or a low second bottom a sandy-textured soil is developed, which, had it occurred more extensively, would have been mapped as Miami sandy loam.

The clay upland of the interstream areas represents that portion of the drift that has not been modified by stream action, the principal change since the time it was laid down being due to swampy conditions that have prevailed in the poorly drained depressions. (See Pl. XXIV, fig. 1.) The upland, which is locally known as the "third bottom," in its naturally drained portions gives rise to the extensive and agriculturally important Miami clay loam. The depressions where swampy conditions once obtained are occupied by rich black soil, mapped as Miami black clay loam.

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The stream valley areas as well as the uplands are quite generally underlain by gravel; but while the material is the same, the mode of occurrence is very dissimilar. Under the valley areas there is little if any stratification, although the beds are supposed to be the result of a reworking by the streams of the stratified portion of the glacial drift and of the superimposed bowlder clay. The present soil covering of the valleys is thought to have been laid down when the terraces successively formed the flood plains of the streams. On the higher terrace, which is no longer subject to overflow, 2 to 4 feet of reddish clay and silt mixed with from 5 to 20 per cent of gravel was deposited. Where the river is not leveed the lower terrace is still subject to overflow, and the upbuilding of the soil is still going on.

The rocks of the area afford lime, cement, and building stone of various kinds. The black shale, outcropping near Columbus, is ground and used in the manufacture of brick, but the greater part of the clay used in the making of tile and brick comes from the yellow clay subsoil of the uplands.

SOILS.

The soils of the Columbus area are all derived from the weathered glacial drift, modified in the case of some of the types by stream and swamp action. The soil types, four in number, have all been recognized before, being similar in origin, texture, and crop adaptation to the soils mapped in Montgomery County, Ohio, during the season of 1900.[a] All the soils of the area are fertile and important agriculturally.

The appended table gives the extent and proportion of the whole area of the several types.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami clay loam	222,336	73.6	Miami gravelly loam	18,941	6.3
Miami black clay loam	33,792	11.2	Total	301,952	
Miami loam	26,880	8.9			

MIAMI CLAY LOAM.

The Miami clay loam is the most extensive of the soil types mapped, occurring as clay uplands between streams and covering about 74 per cent of the area. It consists of from 10 to 12 inches of a yellowish silty loam underlain by a stiff, mottled yellow clay subsoil, which in turn generally grades into the bowlder clay substratum. Sometimes gravel, rock fragments, and bowlders are present on the surface to an appreciable extent, but such occurrences are infrequent and such areas

[a] See Report on Field Operations of the Division of Soils, 1900, p. 85.

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may be considered one of the rare variations rather than a feature of the type.

Along the larger streams, like the Scioto River and Big Darby Creek and their principal branches, the Miami clay loam is sometimes underlain with a well-defined stratum of gravel and sand, often several feet in thickness. This constitutes one of the principal variations of the substratum of the Miami clay loam, but it is in only a small portion of the area in the aggregate. It is important, however, in that it improves the drainage of a type usually deficient in this essential point.

Another variation of the typical section is where the Miami clay loam rests directly on the rock floor. Such occurrences are found in the north central and northeastern portions of the area. In such cases the type is often marked by the presence of 5 to 15 per cent of small fragments of shale and sandstone, derived evidently from the underlying rock and mixed with the clay during the period of glacial action.

The type as a whole is remarkably uniform in texture as well as in color, which is usually yellow or pale yellow. It is also quite evenly distributed throughout the area, the interstream areas being always of this type except in the depressions where swampy conditions have given rise to a black soil—the Miami black clay loam. There is, however, a decided demarcation in point of fertility between the darker, richer yellow colored soil usually found in the better-drained situations along the larger streams, and some of the whitish-yellow soils more typical of the areas remote from the streams. In some cases the darker-colored areas extend considerable distances back from the streams into the upland. The better natural drainage makes the reddish-yellow soils usually more friable and earlier.

The surface of the Miami clay loam is on the whole rather flat, especially in the locations more remote from the larger streams. Near the streams the surface becomes gently rolling, or, as is the case along the Scioto River and Big and Little Darby creeks, even very hilly. The natural drainage is poor, except near the streams, and artificial drainage has to be practiced on all the more level areas in order to insure good crops.

The Miami clay loam is derived from the weathering of the drift material laid down at the close of the Glacial epoch. This drift consists of a yellow clay grading into the unchanged bowlder clay at a depth of from 3 to 6 feet. The more general forces alone have operated in the formation of this type, and only along the drainage channels has the soil been modified by stream action.

The original forest growth consisted largely of the hard-wood trees common to the State, namely, several varieties of oak, sugar maple, soft maple, beech, basswood, black walnut, poplar, wild cherry, white

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and black ash, black gum, elm, hickory, buckeye, and ironwood. No native growth of the evergreens, such as the pine and cedar, occurs in this area. Occasionally a small sugar-maple grove is seen, from which a profit is realized by the sale of sugar and sirup.

The Miami clay loam may not be regarded as a naturally fertile soil, because of deficiency in organic matter, but its texture is such that it can be brought up to a high state of fertility. The dark-yellow colored soil is apparently naturally the more fertile, producing crops possibly 10 per cent in excess of the yields on the whitish-yellow soil, but this seeming advantage is doubtless due in part to better natural drainage, which makes the soil more easy to keep in proper tilth and allows it to be cultivated earlier in the season. On the other hand, the light-colored soil sometimes has a peculiar, waxy texture and is very refractory in tillage. In wet weather such soil runs together like wax, drains very slowly, and if plowed at such times clods, when the preparation of a proper seed bed becomes difficult and expensive. The addition of manure, a wise system of rotation, and good artificial drainage have in many cases partially corrected this undesirable character of the soil.

The Miami clay loam as a whole seems well adapted to general farm crops. The grasses and small grains do well, and much corn is grown also. Wheat yields from 20 to 35 bushels per acre, and crops of from 40 to 50 bushels have been grown by some more expert farmers in favored fields. Oats yield from 40 to 60 or more bushels and corn from 40 to over 100 bushels per acre. The rotation practiced by many farmers is (1) corn; (2) grain—such as wheat, oats, or rye, on which is seeded, in the spring usually, a mixture of clover and timothy; (3) hay and pasture, which in turn is followed by corn.

The wheat is sometimes exchanged for flour at the small grist mills, but this practice is not so common as formerly, as custom mills are less numerous. The corn is consumed largely on the farm by hogs and beef and dairy cattle.

Millet and fodder are grown for hay and ensilage to supplement the permanent pastures, and where sheep are kept rape is used for this purpose.

Orchard fruits and small fruits seem to do very well on this type of soil, and orchards are a common feature of the homestead.

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The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Miami clay loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6957	2 miles NW. of Alton.	Silty loam, 0 to 10 inches.	2.18	1.02	2.82	3.08	10.32	10.48	53.74	18.50
6961	1 mile NE. of Georgesville.	Brownish silty loam, 0 to 12 inches.	1.76	.64	2.20	2.46	8.04	10.94	55.86	20.10
6963	2 miles NE. of Reynoldsburg.	Light-yellow silty loam, 0 to 10 inches.	2.05	1.00	2.32	1.86	5.74	10.10	57.14	21.96
6958	Subsoil of 6957......	Reddish clay, 10 to 36 inches.	1.18	.50	3.14	2.60	8.02	9.78	42.30	33.64
6964	Subsoil of 6963......	Reddish-brown clay, 10 to 36 inches.	.81	.80	2.44	2.44	8.30	11.44	39.90	35.02
6962	Subsoil of 6961......	Reddish-brown clay, 12 to 36 inches.	.70	.84	1.94	1.74	5.98	8.10	41.84	39.40

MIAMI BLACK CLAY LOAM.

The Miami black clay loam consists of from 10 to 20 or more inches of black loamy clay underlain by a yellow or sometimes dark-bluish clay subsoil. It occurs in two principal areas, one in the vicinity of Derby and the other south of Dakrumm, and small areas, from 5 to several hundred acres in extent, are frequently found throughout the area surveyed, being associated with the level tract of the Miami clay loam and also occurring as narrow strips along the smaller drainage ways. The local variations in texture are not very great. Gravel, rock fragments, and bowlders sometimes occur, as in the Miami clay loam, but on the whole the Miami black clay loam is remarkably uniform and quite free from rock fragments or gravel of any kind. In the small areas, the surface soil is underlain by a yellow clay subsoil similar to the subsoil of the Miami clay loam; but in the two large, well-defined areas from 2 to 3 feet of black clay loam may be found before the underlying yellow clay is reached.

The areas of this type, as would be expected, are flat and noticeably basinlike, lying from 1 to 3 feet below the surface of the surrounding Miami clay loam. Within the last twenty or thirty years, many of these depressions held standing water, from 1 to 2 or more feet deep, nearly the whole season through. Now these depressions have nearly

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all been drained and put under cultivation by the use of tile under the land, connecting with open ditches leading to the natural drainage channels.

The Miami black clay loam owes its origin to depressions left in the glacial drift. These have gradually been filled in by wash from the surrounding lands and long accumulation of the remains of aquatic plants, the depressions originally lacking drainage and containing more or less water. The resulting soil is the dark, remarkably fertile clay of loamy texture mapped under the name of this type.

The Miami black clay loam, by reason of the large amount of vegetable matter and usually abundant moisture supply, is one of the strongest soils in this area. It seems especially adapted to corn, but, so far as its fertility and texture are concerned, it is also well suited to general farm crops and small fruits. Because of the tendency of the soil to "heave" during the alternate freezing and thawing of the winter season, such crops as clover and winter grains are liable to suffer injury. After the soil has been drained and brought under cultivation, it becomes more compact, by reason of the breaking down or readjustment of the vegetable mold, and less injury is found to result to winter crops.

This soil is the typical corn land of the area. The reported yields of corn range from 40 bushels to 120 bushels, and of wheat from 20 bushels to 40 bushels per acre in favorable seasons. When the season is too wet, as is occasionally the case, grain crops are liable to lodge some.

A weed very generally noticed, which seemed peculiar to this type, was the common milkweed (*Asclepias syriaca* L.). This weed springs up from underground rootstalks and escapes destruction from the ordinary vertical-toothed cultivator. Another weed noticed, and evidently difficult to eradicate, is the common pokeweed. Rotations involving the plow or knife cultivator seem to be about the only effective way of holding these weeds in check. In pasture land they are very persistent, as neither cattle nor sheep seem to eat them.

The farm buildings are not usually located on this type, but rather on the adjoining Miami clay loam.

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The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Miami black clay loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6951	1 mile W. of Derby.	Black clay loam, 0 to 12 inches.	4.48	0.20	0.94	1.10	5.48	6.06	64.78	21.44
6953	1¼ miles NW. of Derby.	.....do..............	4.21	.18	1.62	1.72	7.76	7.80	59.12	21.66
6955	2 miles SE. of Dakrumm.	.....do..............	6.20	.96	2.58	2.02	6.26	7.94	57.74	21.76
6954	Subsoil of 6953......	Dark mottled-yellow clay, 12 to 36 inches.	1.39	.64	1.62	1.00	3.70	5.92	65.78	21.22
6952	Subsoil of 6951......	....do...............	1.22	.16	.60	.54	4.08	5.62	67.28	21.72
6956	Subsoil of 6955......	Clay, 12 to 36 inches.	1.75	1.60	3.06	2.24	5.18	7.06	52.42	28.24

MIAMI LOAM.

The Miami loam consists of 8 to 12 inches of a dark sandy loam, underlain by a black clay loam. Oftentimes there is little or no difference between the soil and subsoil—a black, moderately heavy loam extending to a depth of 3 feet or more. Usually this material is underlain by a bed of limestone gravel.

The Miami loam is remarkably uniform as to texture. The only variations are where the soil is slightly more sandy or in small local areas, where it has a mucky texture. Occasional gravel spots, from 1 to 2 acres in extent, are also found. The gravel content in such cases ranges from about 10 to 30 per cent.

The type occurs as the lower terrace along all the larger and nearly all the smaller streams. The surface is generally very flat, with, however, an occasional area of gently rolling character. The elevation above the stream beds varies from about 8 to 20 feet, the greater portion being usually less than 20 feet, and the type is thus subject to overflow by spring freshets where not protected by levees.

The Miami loam owes its origin to stream deposits of silt and clay, laid down during the spring floods when the waters extended far on each side of their normal channels. As the floods receded later in the season, aquatic plants and rank vegetation sprang up and were buried beneath another deposit of clay and silt by the following season's overflow. This process, continued for centuries, has resulted in the forma-

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tion of the deep, rich, black soil of the Miami loam, now overlying to a depth of from 2 to 6 or more feet the gravel floor of what was probably a larger stream.

Very little of this soil is in forest, as it is in great demand for cultivation. A dense growth of oak, black walnut, sycamore, and hickory once grew on these river bottoms, and fragments of these forests may now be seen fringing the streams. Before the land was cleared the forest sometimes held the flood water nearly the whole season through, but since the clearing of the land, the construction of ditches, and the laying of tiles the drainage condition of the type has become quite good.

The areas of Miami loam vary in width from one-eighth mile to 1 mile, extending from the streams which they border back to the gravelly second bottoms and clay uplands. (See Pl. XXIV, fig. 2.)

The levees, which are extensive and from 8 to 15 feet in height, are usually built by individual owners or through cooperation of several owners of the lands benefited, and not by a system of taxation, as is the case in the States bordering the Mississippi River, where levees may benefit lands 50 or more miles back from the river.

The Miami loam is especially adapted to corn and late vegetables. It is not so well suited to the production of the winter grains and clover, for the reason that there is possibility of flooding from stoppage of the drainage channels during the winter, from a break in the levees, or from unusually high water in the spring. There is not the same injury from "heaving" with this type as there is with the Miami black clay loam.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Miami loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6967	3 miles NW. of Groveport.	Dark loam, 0 to 12 inches.	5.80	0.16	0.82	0.60	1.64	4.00	72.16	20.40
6965	1 mile S. of Columbus.	.....do..............	3.48	.44	1.10	1.00	9.60	18.78	44.72	24.28
6966	Subsoil of 6965......	Dark-brown clay loam, 12 to 36 inches.	3.60	.00	.38	.20	2.22	5.20	66.68	24.96
6968	Subsoil of 6967......	Dark-brown loam, 12 to 36 inches.	2.79	.06	.32	.14	.70	4.36	64.54	29.46

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MIAMI GRAVELLY LOAM.

The Miami gravelly loam consists of from 10 to 12 inches of reddish clay loam underlain by a stiff, buff-colored or reddish clay subsoil, beneath which is usually found a well-defined gravel bed. The gravel is usually limestone, and the stratum also contains rounded bowlders, the matrix being sand and clay. The gravel content of the soil and subsoil varies from about 10 per cent to 30 per cent, the quantity of gravel in the soil seldom being so great as to interfere much with tillage.

The type is locally known as "gravelly second-bottom land." It occurs as terraces along nearly all the streams, and lies several feet above the Miami loam terrace, being 20 to 60 feet above the stream beds. Lying as they do in generally narrow stream valleys, the areas of this soil, like those of the Miami loam, are never very wide, nor does the former occur so much in the form of continuous strips as the latter.

The surface is sometimes quite flat, but usually it is gently rolling. The natural drainage conditions are very good, both by reason of the surface conditions and because of the gravel stratum which underlies the type.

This soil type is derived from the weathering of the material forming the gravelly second bottoms. These second bottoms owe their origin to an action similar to that noted for the Miami loam, with, however, the exception that conditions were such that no great accumulation of vegetable matter took place, probably because of the better natural drainage of these high terraces. At the close of the Glacial period the whole of the area was more or less uniformly covered with several feet of yellow clay drift. After a time drainage ways began to form, finally resulting in the present well-defined channels. The streams were doubtless greatly swollen during much of their early history, and owing to the swift currents clay and silt were carried away, while extensive beds of gravel remained, forming the floor and sides of the streams. As the streams cut deeper and became reduced in volume these gravel beds became subject to overflow only during floods, when a deposit of clay and silt was effected. Thus the formation of the Miami gravelly loam and the Miami loam terraces took place in the same way, the only differences being the greater quantity of gravel and less amount of vegetable matter accumulated in the soils of the higher-lying terrace.

As might be inferred from the similarity in origin of these two soils they not infrequently grade into each other, and the change from one type to the other is so gradual as to make the determination of the boundary lines quite difficult. Still, on the whole, the local variation of the Miami gravelly loam is very slight, and the type characteristics are fairly distinct throughout the area surveyed. A slightly sandy texture is sometimes found, in which case the drainage is apt to be excessive and the soil more liable to be droughty.

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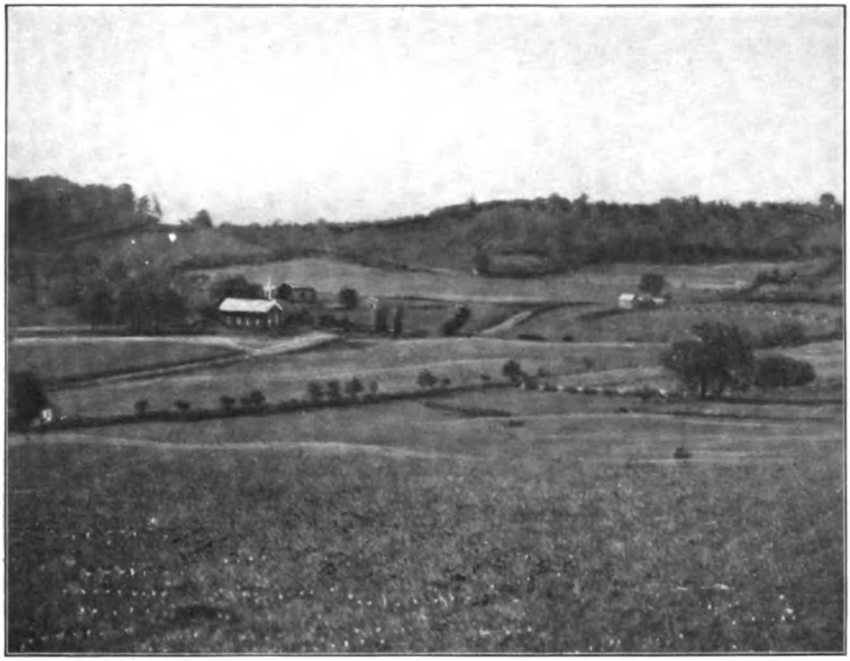

FIG. 1.—GENERAL VIEW OF THE UPLANDS, SHOWING THE ROLLING CHARACTER OF THE COUNTRY, COLUMBUS AREA, OHIO.

This is the Miami clay loam, the principal wheat soil of the area. Not so well adapted to corn as the Miami black clay loam.

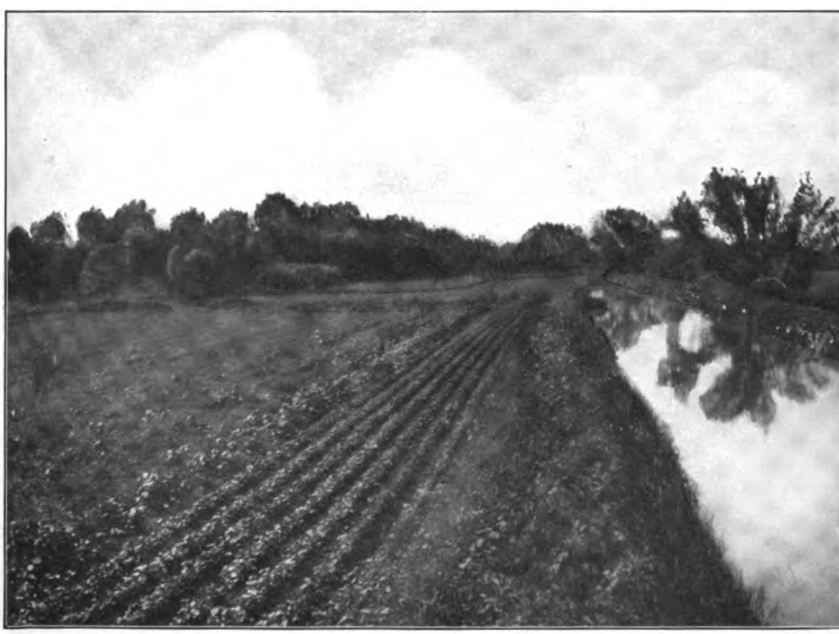

FIG. 2.—MARKET GARDENING OF THE MIAMI LOAM, COLUMBUS AREA, OHIO. THE FIRST TERRACE.

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The Miami gravelly loam is the leading market-garden soil of the area, being used for this purpose to a large extent in the vicinity of the larger towns, especially Columbus. It is also well adapted to the general farm crops. The excellent subdrainage afforded by the gravel substratum, and the clayey texture of the overlying soil and subsoil is an ideal soil structure. Such a soil warms up quickly in the spring, readily parts with its excess of water, and yet retains sufficient moisture to supply the ordinary needs of the crop. The more successful gardeners, however, irrigate their fields, generally by means of water pumped from wells into tanks by windmills. Water is usually reached at from 8 to 20 feet below the surface.

The market garden crops consist chiefly of onions, lettuce, tomatoes, radishes, melons, cabbage, sweet corn, potatoes, beans, and peas, all of which seem to thrive. When the location does not favor gardening, such crops as corn, wheat, and grass, and tobacco are successfully grown on this soil. Corn yields from 40 to 60 bushels, and wheat from 15 to 25 or 30 bushels per acre. Sorghum also does well. Naturally the soil is better adapted to early maturing crops than to crops that mature late in the season, as the perfect drainage is apt to produce a droughty condition in long periods of dry weather.

These second bottoms were much sought after by the early settlers because of their productiveness, and they soon became cleared and tilled, leaving little of the original forest growth standing.

The Miami gravelly loam makes an ideal location for the farmstead. The natural drainage is good, and the underlying gravelly loam affords a near supply of good drinking water. Many fine farm buildings are seen on this type, usually with surrounding apple and cherry orchards, well-kept gardens, and patches of small fruits.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Miami gravelly loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6971	2¼ miles S. of Columbus.	Brown gravelly loam, 0 to 10 inches.	1.11	4.40	11.20	5.94	9.56	5.60	45.26	17.94
6969	2 miles W. of Brice.	Dark silty loam, 0 to 10 inches.	1.17	5.56	7.22	3.50	4.82	6.20	40.94	31.20
6972	Subsoil of 6971.....	Reddish-brown clay with gravel, 10 to 36 inches.	.68	3.52	12.10	6.40	11.40	8.04	38.62	19.36
6970	Subsoil of 6969......	Reddish clay, 10 to 36 inches.	1.62	7.14	12.60	5.98	5.86	3.76	31.14	32.42

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DRAINAGE.

The first drainage of the soil in the vicinity of Columbus for agricultural purposes was undertaken about forty years ago. To-day it is estimated fully a fifth of the area surveyed, including the lands most in need of drainage, is underlain by tile drains.

The soils naturally most in need of drainage are the Miami black clay loam and the Miami clay loam, both situated in the upland or interstream areas. The surface of these soils is generally flat, though modified by low undulations from 5 to 10 feet high and by small natural drainage channels that lead to the larger streams and rivers of the area. These natural drainage channels are utilized as main drains, in a large measure taking the place of the extensive private and county ditches that must be dug as a preliminary to thorough tile drainage in the more level areas of northern Ohio. Occasionally, however, an extensive flat area is found where wide, deep, open ditches are necessary. Sometimes the owner or owners of the lands to be most benefited take the matter in their own hands and build the ditch. Sometimes the landowners petition the county commissioners for a drain, and they direct the county surveyor to lay out the course of the ditch and set the grade stakes, as well as to apportion the assessment for construction against the adjoining lands, as nearly as possible in proportion as they are benefited by the ditch.

The two types of upland soil pointed out as deficient in drainage are so because of the impervious character of their clay subsoil and by reason of their topography. Of the two, the Miami black clay loam has been the most benefited by underdrainage, in many cases the areas having formerly been under water for the greater part of the growing season. The thorough tile drainage of such areas has changed the soil to one of the best in the area for corn and one excellent for grain and grass. Two main effects are responsible for the improvement—the removal of standing water and the reduction of damage from "heaving" caused by the freezing and thawing of the soil when in a too saturated condition.

That tile draining should greatly benefit these areas of heavy clay soil, lying for the most part in depressions generally swampy and frequently covered with water, would naturally be supposed, but that the higher lying Miami clay loam would be very much improved by tiling is less easily surmised. This has been found to be the fact, however, and tile drains are being extended into the flatter areas of this soil as rapidly as time and means permit.

The quality of crops grown on the underdrained soils is improved and the yield is increased. On the Miami black clay loam the increase in value is said to be 50 per cent and on the Miami clay loam from 10 to 30 per cent over the crops produced on the same fields before draining.

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The "second bottoms," where occurs the Miami gravelly loam, are usually well drained naturally, but the "first bottoms," in which is found the Miami loam, when so situated that an outlet can be had, are drained, and with profit. The improvement in the condition of this soil by drainage is said to be about the same as in the case of the Miami black clay loam.

It is not within the scope of this report to go into the details of installing a drainage system, nor is it practical to give the cost of putting in such systems, as each one must vary with the character of the soil and topography. The heavier the soil the closer together must be the drains, and in the flatter areas of Miami black clay loam it has been found that a drain is not effective for a greater distance than a rod on each side. Even with the low cost of tile in this area the cost of thoroughly underdraining an acre is quite large.

Tiles are manufactured in the area from the clay found in the subsoil of the uplands. At one time there were 17 factories, large and small, in operation in Franklin County alone. Now there are perhaps 5, all large and well-equipped concerns.

The price of tile as given by one of these ranges from 20 cents per rod for 3-inch tile up to $4.50 for 20-inch tile. The large sizes are now being used for main drains, instead of open ditches.

The tile drains have proved to be very durable. Drains laid twenty or thirty years ago are apparently in as good condition to-day as they were when put in. They can thus be classed as one of the most permanent improvements that can be put on the farm, while the practical results of their use in the production of crops have proved them to be one of the most valuable. Throughout the area the condition of the land with respect to drains has become an important factor in determining its value in the market.

With a fifth of the area already tile-drained, and with the rapid extension of the system now going on, it is thought to be only a question of a comparatively short time when the remainder of the area, excepting of course those lands with a porous structure and a gravelly subsoil, will also be improved in like manner.

AGRICULTURAL CONDITIONS.

The farmers of the Columbus area are quite prosperous. Mortgages on farms are being paid, improvements added, and machinery purchased. The better and more intensive tilling of the fields is also an indication of a thriving industry. It is said that the conditions now are much better than one or two decades ago.

The size of the farms varies considerably, ranging from 20 acres to perhaps 500 acres. The area of the greater number ranges from 50 to 140 acres. The average size for Franklin County, computed from figures furnished by the Twelfth Census of the United States, is 84.41

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acres, which doubtless represents fairly accurately the average for the Columbus area.

The farmstead usually consists of from 5 to 10 acres, with a substantial frame or brick house, a barn and shed, and other outbuildings. Native shade trees and thrifty orchards of fruit trees usually surround the farm buildings.

The houses range in value from $800 to $3,000, the average being probably between $1,000 and $1,600. The barns are good, substantial structures, though generally less expensive than the houses, in this respect differing from the barns found in Lancaster County, Pa., and in some other parts of the East. The farm buildings, both houses and barns, are nearly always well painted. Nearly all the farms are fenced. The old-style worm-rail fence and the modern wire fences are found side by side, but the latter are gradually displacing the former.

The acre valuation of the land, taking the area as a whole, ranges from $40 to $120, depending on improvements, location, and character of soil. The usual asking price is from $60 to $100 per acre. The tax rate, local and State, is about $1.50 per $100 valuation. The valuation is usually about 60 per cent of the price of the land at forced sale.

Nearly every farm in the area is well equipped with plows, harrows, grain drills and binders, cultivators, mowing machines, wagons, and lighter vehicles, and very few places were noted where these were not properly housed when not in use.

According to the Twelfth Census, 72.5 per cent of the farms of Ohio are operated by the owners, while of the remainder 8.7 per cent are operated by tenants paying a money rental and 18.8 per cent by tenants on shares. These figures probably represent fairly well the conditions of tenure in the Columbus area. The money rental of land ranges from $4.50 to $6.50 per acre per season, any higher rate being usually unprofitable to the tenants. When rented on the share basis the owner receives about two-fifths of the crops. In the census figures just quoted managers of farms are included in the percentage of farms operated by owners. The suggestion is made that the number of farms that are being operated by "managers," who may or may not own a part interest in the farm, is increasing. The Twelfth Census also gives the percentage of gross income of the farmers, figured on the total investment, as 16.8 per cent. The average net income is not given, but it is, of course, very much below this figure.

The condition of the industry with respect to labor can not be said to be entirely satisfactory. The supply during most of the year is ample, but at times, during harvest, help is scarce and wages high. The wages by the month with board range from $16 to $20 and by the day during harvest from $1 to $2. The labor is usually white, and as

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far as quality of work is concerned is more dependable than that available in some parts of the country, but there is a great difficulty in getting men to stay long in one place. The hired-girl problem is not entirely to the satisfaction of the average housewife. Such help is scarce. The wages paid girls range from $1 to $3 per week, with board included, of course.

The principal products of the area outside of the zone of city influence are grain, beef, mutton, pork, butter, and cheese. The crop rotation followed is nearly always: (1) corn, (2) grain, either wheat, oats, or rye, and (3) grass, usually a mixture of clover and timothy. As will be noticed, the rotation allows considerable variation in the kind of grain grown, and the farmer also varies the length of time the land is left in grass to suit his needs; but in the main this rotation is followed and has been found essential to keeping the land in good tilth.

In any case the wheat crop represents the direct money crop. It is frequently sold to the local elevators at from 50 to 80 cents a bushel. The yield per acre ranges from 15 to 25 or 30 bushels. The corn and hay crops are also sold direct when not needed for feeding and fattening stock, but generally these crops are turned into beef, dairy products, pork, and mutton. Cattle to be fattened are usually put in pasture during the summer and fall and then fed in the late fall and winter with a liberal ration of corn. Pasture is sometimes supplemented by corn fodder. The herds of beef cattle seen usually number from 6 to 30 head.

The dairy interests are not very extensive. Only four creameries were noticed in the area. Each farmer, however, has from 1 to 6 cows, and in the aggregate the product of milk and homemade butter is considerable. The greater part of this is taken for local consumption. Large herds of dairy cattle are uncommon.

Many flocks of sheep, ranging from 40 to 100 head to the flock, are seen. It is said that the keeping of these is quite profitable. In most cases the sheep are raised chiefly for mutton, but some breeders are producing a mutton sheep with a fine-textured fleece, thus making the wool product more profitable than when a strictly mutton sheep is raised.

Fruit also does well in the district and is fairly well represented on most of the farms. Apples, pears, peaches, raspberries, strawberries, and currants appear to be best adapted to the soils and climate. More attention seems to be given to this industry than formerly. A great many of the apple orchards are old, but young orchards are at present being set out in many places. There is doubtless good profit in rational orcharding upon the soils of this area. One case was found where $450 net profit in one season was realized from a 3-acre apple orchard. This, of course, is rather exceptional, but it is an index of what may be done in the production of apples in the area surveyed.

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The market-gardening interests in the vicinity of the larger towns, especially Columbus, is very large. Great quantities of onions, lettuce, radishes, cabbage, tomatoes, etc., are grown on the various soil types. Such farms range in size from 5 acres to 40 acres, and the gross income varies from $200 to $800 per acre. One man is reported to have secured a net income of $600 per acre for his onion crop. This, too, is merely an index to the profit to be made in producing the truck crops.

The origin of the soil types of the Columbus area is more clearly marked than in some of the other areas surveyed, and the adaptation of these soil types to certain crops seems also more pronounced. The Miami clay loam is the typical wheat and grass land, though as manipulated by some of the more successful farmers most of the staple crops, including even the truck crops, are grown with success. The Miami black clay loam, occurring in the depressions of the clay uplands, is the typical corn land of the area, yielding from 60 to 120 bushels per acre. By reason of its heaving in winter, such crops as the grasses and grains are liable to suffer serious injury, and, moreover, grain is liable to run too much to straw. With good drainage and careful tilling these undesirable features are being gradually modified. The Miami loam, which occurs as the lower-lying terraces along streams, where not leveed as before pointed out, is subject to overflow in the spring. It also is used mainly for corn. Wheat and grass are not grown extensively on this soil because of the danger from floods, while corn is secure, since it is planted after danger of spring freshets has passed. This type contains considerable decaying vegetable matter, but still has sufficient sand to prevent injury to grass and grains by heaving. When leveed good crops of wheat and oats are grown. Some excellent truck crops are grown on the more favored portions of this type near Columbus.

The crops adapted to the Miami gravelly loam are especially truck crops, though this type is also used for general farming. Good subdrainage is always a feature of this type and hence crops are not apt to suffer from too much rain, while on the other hand plenty of good water is found at a depth of from 8 feet to 20 feet and is thus near at hand for the pump and tank irrigation practiced by the more progressive truck farmers. Where irrigation is not practiced the type is limited in its adaptation, by reason of its droughty character, to crops which mature early, such as grain and some of the small fruits, especially strawberries.

Thus we have before us four soil types showing marked adaptability to certain crops. Under the manipulation of the more progressive farmers these natural adaptabilities have been widened as well as intensified on all the types. Large quantities of manure and fertilizers are added to the soil, especially where truck is grown.

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The transportation facilities of the area are very good. Columbus is a notable railroad center. Some twenty or more railroads either enter or have connection with that city. Besides these, a number of excellent trolley lines reach out from Columbus to the smaller cities and towns, and even to some of the more distant cities—Springfield and Dayton, for instance. Farmers located near the trolley lines are able to use them in sending to market fruit, truck, and dairy products. This means of communication, coupled with the ever-extending telephone service, makes possible a ready intercourse for business and pleasure that was unthought of a decade ago. In addition to the already-mentioned means of intercourse and commerce the rapid extension of a daily rural free-delivery mail service, bringing to the farmer his daily papers and business letters, is worthy of special mention. The railroad, the trolley, the telephone, and the daily mail are helping to take the farmer out of that isolation which was formerly his lot here and is still his misfortune in less favored sections of the country, and to bring him in closer touch socially and commercially with the outside world.

Nearly the whole area is reached by good wagon roads. These are often surfaced with gravel or crushed limestone, while the dirt roads are kept in good repair by the occasional use of modern road implements.

Columbus, with its population of about 127,000, is the principal market town of the area. There are in the area about a dozen small towns, with populations ranging from 200 to 1,000, which consume some of the produce of the area and are shipping points, but they may be regarded rather as feeders to the Columbus market. A number of wagons driven about the county in quest of poultry and dairy products were often seen during the progress of the soil survey. On the whole the condition of the area with respect to markets may be considered quite good.

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SOIL SURVEY OF UNION COUNTY, KENTUCKY.

By HERBERT W. MAREAN.

LOCATION AND BOUNDARIES OF THE AREA.

Union County embraces an area of about 361 square miles, lying near the western end of Kentucky, about midway between the Green and Cumberland rivers. Along its northern and western borders, for a distance of about 36 miles, flows the Ohio River. To the southwest lies Crittenden County, from which it is separated by the Tradewater River. Webster County borders it on the southeast and Henderson on the northeast. Morganfield, the county seat, has a population of about 2,000, while Sturgis and Uniontown stand next in size and importance. (See fig. 11.)

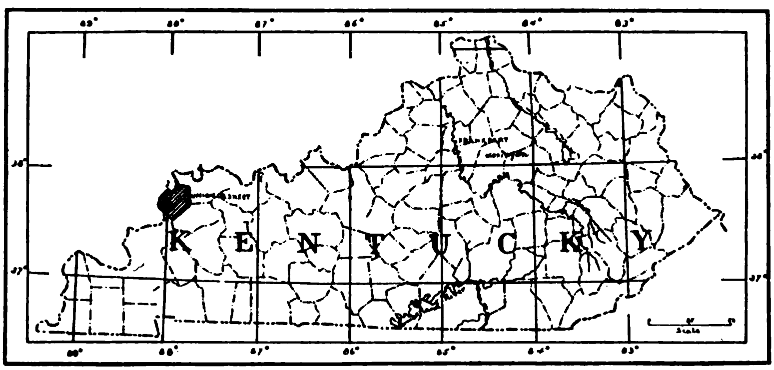

FIG. 11.—Sketch map showing area surveyed in Kentucky.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Union County was laid off from Henderson County in the year 1811. The first permanent settlement in the region was made about the year 1805. Previously to this the territory had been visited by immigrants who did not remain long, but pushed on farther west or returned to their homes in the East. The earliest settlers were from Virginia and North Carolina. They were of two classes. The first class took up lands under army grants made by the Government in recompense for services rendered during the Revolutionary war. Large tracts were laid out by this "military survey" comprising claims of from 1,000 to 1,200 acres each. The other class was composed of those who settled under

the so-called "head-rights" law, by virtue of which a squatter might claim title to a certain portion of land, provided that he could prove that he had actually settled on it and made certain improvements. This law, because of its breadth and liberality, was the cause of great injustice. Many succeeded in gaining possession of large tracts of land by doing little more than piling up heaps of brush and burning them.

The life of the early settler was the life of the frontiersman of that day. Dense forests covered the land, inhabited by an abundance of wild game which was depended on in part for the food supply. The first lands to be settled were the uplands and ridges. The lowlands and stream bottoms were covered by swamps and bogs, and the early farmers sought the higher and drier localities. As fast as the land could be cleared of its growth of timber agricultural pursuits were begun. Slave labor was employed from the first and the crops grown were corn and tobacco, with some oats. Corn furnished food for man and beast, and tobacco was the money crop with which other necessities could be bought.

The fertility of the soil attracted more immigration and the country was quite rapidly developed. Stock raising was an important industry then, as it is now. Hogs were chiefly raised, although the grazing of cattle and sheep was also followed. It was not until about the middle of the nineteenth century that wheat growing became an important industry, but since then this and the raising of beef cattle have steadily increased in importance.

The rapid settlement of the more desirable portion of the uplands naturally led to the development of the lowlands and bottoms, and through ditching and drainage this very fertile part of the country has been opened up. At the present time a large proportion of all the bottom lands has been reclaimed. These are generally considered the most desirable lands for general farm purposes.

CLIMATE.

There being no Weather Bureau station in Union County, Ky., the table given below, showing normal temperature and precipitation, presents the figures for Weather Bureau stations at Fords Ferry, situated in Crittenden County, just south of Union County, and Henderson, lying north of the area, in Henderson County. It is believed these readings, differing so slightly as they do, may be safely applied to the intervening territory.

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Normal monthly and annual temperature and precipitation.

Month.	Temperature.		Precipitation.	
	Fords Ferry.	Henderson.	Fords Ferry.	Henderson.
	°F.	°F.	*Inches.*	*Inches.*
January	36.3	36.6	3.85	3.86
February	34.3	34.9	2.61	2.64
March	47.6	47.8	5.09	5.58
April	57.6	58.7	4.05	3.41
May	67.3	68.1	4.25	3.99
June	76.6	77.1	3.52	4.46
July	78.5	78.1	4.04	4.10
August	78.6	79.1	1.71	2.28
September	72.6	72.7	2.56	2.42
October	59.1	60.3	2.55	3.19
November	46.9	47.2	3.74	3.74
December	37.5	37.9	3.06	3.65
Year	57.7	58.2	41.08	43.32

The average length of the growing season as deduced from records of the same stations is about one hundred and eighty days. At Fords Ferry the average date of last killing frost in spring is April 13, and of the first in fall October 8. In the case of Henderson the figures are April 6 and October 25, respectively.

PHYSIOGRAPHY AND GEOLOGY.

The rocks underlying all the soils of Union County are sandstones and sandy shales belonging to the Carboniferous group of sedimentary rocks, or Coal Measures. The county lies within the district known as the western coal region of Kentucky, and is plentifully supplied with an excellent grade of bituminous coal. Many mines are in active operation and furnish the best of fuel at a reasonable price, compensating for the lack of firewood, which is becoming scarce in this section of the country.

Along the Ohio River bottoms are found deposits belonging to more recent geological groups. These are in the form of river sediments and give rise to the sandy and clayey soils of that district. The geological relations of the soils of the upland part of the county are somewhat obscure. Although the underlying rocks are of a distinctly sandy nature, the soil contains practically no sand whatever, but is made up almost entirely of silt. Again, while the outcrops of bed rock in different sections of the area show considerable variation in character, the texture and agricultural value of the soil overlying these rocks show remarkable uniformity. Therefore it is necessary to conclude that the soils of Union County are not residual in the sense of being derived by disintegration from the underlying rocks, but that they are derived from a loesslike covering or mantle.

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The term "loess" is used by the geologist in this country to designate a mantle of unconsolidated material covering large areas along the Mississippi Valley from the Great Lakes to the Gulf of Mexico and extending for many miles to the east and west along the larger tributaries of the Mississippi River. It is supposed to have been derived from glacial débris, transported by the ice sheet when the glacier invaded the northern part of the continent in the Quaternary period. It is thought to have been laid down partly by water deposition and partly by æolian agencies, but authorities are not agreed upon this point. But that the upland soils of this region are of loess origin is proven by many facts, as the uniformity of texture extending over large areas, the predominance of silt and the absence of coarse sand and gravel in the composition of all the soils, and the nonconformity between soil and underlying rock. Furthermore, in several deep cuts along the bluff that separates the upland from the river bottom the exposed subsoil shows the typical loess texture and is distinctly stratified. From these several facts we are forced to conclude that the upland soils of Union County are not the product of rock disintegration, but are derived primarily or secondarily from the loess.

The county may be divided into two main physiographic divisions—the upland, embracing the larger area, and the Ohio River bottom. The river bottom stretches in a belt varying in width from one-fourth of a mile to 3 or 4 miles along the northwest, west, and southwest border of the county. It lies in a nearly level plain about 20 feet above the normal water level of the river, but is subject to inundations at times of high water. Running longitudinally along the bottoms are depressions or sloughs from 200 to 300 yards wide that are always wet and boggy. Near the banks of the river are quite pronounced ridges, forming in some instances natural levees, while the land slopes gradually inland, as is usually the case where a stream is subjected to periodic overflow. In several instances there are distinct terraces rising above the general level of the valley, forming the so-called "second bottom."

Dividing the river lowlands from the upland portion of the county is a bluff varying from 50 to 100 feet in height. In the southern part of the county this is a precipitous sandstone cliff, standing up boldly to a height of from 75 to 100 feet above the river; in the northern section the ascent to the upland is less abrupt, and deep cuts show the material to be of typical loess structure. The upland portion of the county varies from a gently undulating plain to a roughly rolling or hilly country. Lying in a belt 5 or 6 miles broad, and stretching from a point about 4 miles west of Morganfield, across the middle of the county to Highland Creek, on the eastern boundary of the county, is a region of gently rolling upland, with broad stream valleys and low, rolling hills. Again, in the southern section, around the

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town of Sturgis and eastward through the Pond Fork district, there is a region of level land. Separating these two areas is a range of hills running in an east and west direction and acting as a minor drainage divide. Following the general course of the Ohio River is a range of hills—the river hills—where the land is more rough and broken. There are differences of elevation of from 100 to 150 feet in the more rugged parts of this area, although the slopes are not steep enough to make cultivation unprofitable. Here the stream bottoms are narrower, but usually there is a belt 200 or 300 yards wide bordering the stream courses. On the whole the topography of the upland is that generally designated as an undulating plain, and is very favorable to agricultural pursuits.

SOILS.

Seven distinct types of soil occur in the Union County area, all of which, with the exception of the Sturgis fine sandy loam, have been correlated with soil types recognized in other surveys.

The following table gives the name and area of each soil and the proportion which each is of the whole area:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami silt loam	154,176	66.7	Sharkey clay	4,032	1.7
Waverly silt loam	25,216	10.9	Miami fine sandy loam	3,072	1.3
Yazoo clay	24,448	10.6	Sturgis fine sandy loam	2,176	.9
Memphis silt loam	17,984	7.8	Total	231,104	....

MIAMI SILT LOAM.

The Miami silt loam, the most extensive and important soil in the area, is the one locally spoken of as "the upland." It is a yellowish or gray silt loam of varying depth, ranging from 6 to 12 inches. It is mellow and open, never bakes into hard clods, and is almost as easy to plow as a sandy loam. The subsoil, however, which is met at a depth of about 10 inches, is more claylike in its properties. Exposures in road cuts show a rather stiff and tenacious red-brown loam made up largely of silt particles. Under this, at a depth of 6 to 10 feet, the soil becomes similar in texture to the surface foot, i. e., incoherent and silty and of a yellowish color. The soil is found throughout the entire upland portion of the county, where it occupies all the features of topography, varying from almost level to the most rolling and hilly areas in the district. It is a well-drained soil and at the same time possesses good water-holding properties. The surface soil is of such character as to allow rain water to enter easily, and this is stored

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up in the more compact subsoil within easy reach of the roots of growing plants. On some of the steeper slopes, however, and where improper methods of cultivation have been practiced, the soil suffers considerably from washing. With care this can be prevented, and even where washing has commenced, if taken in time it can be considerably checked by filling the gullies with straw or by plowing under sufficient quantities of organic matter. If more humus was incorporated annually with the soil, in the form of barnyard manure or decayed wheat straw, of which there is an abundant supply, the tilth of the soil would be so improved as to prevent this washing in a large measure. It is believed that some of the more hilly portions might be profitably made into permanent pastures by sowing to blue grass. Blue grass has been tried with good success in a number of cases.

The whole area of this soil, which is of loess origin, rests unconformably on the underlying sandstone or sandy shale, or upon the residual product of their disintegration. The average thickness of this covering of loess is about 20 feet, though where it has been subjected to more active erosion it is sometimes no more than 2 or 3 feet thick. There are comparatively few rock outcrops and seldom is a stone fragment seen on the surface. A few exceptions to this rule occur in the southern portion of the country, where narrow strips, too small to be indicated on the soil map, are characterized by the presence of considerable quantities of shale, which has worked up from the immediately underlying rock.

The crops at present grown on the Miami silt loam are wheat, corn, grass, and tobacco. The yield of all these crops is good, maintaining an even average through the various seasons. Corn will produce from year to year about 35 bushels per acre, and in good seasons as high as 50 bushels per acre. The quality of the wheat on the upland is superior to that grown on any other soil, though the average yield of 18 to 20 bushels per acre is exceeded by some of the bottom lands. An excellent quality of tobacco of the heavy export type is grown, the product being from 1,000 to 1,500 pounds per acre, with an average yield of 1,100 or 1,200 pounds per acre. Clover has been the great hay crop of this country, but of late the farmers have had difficulty in obtaining a good stand. It is probably an instance of the soil becoming "clover sick," a condition of not uncommon occurrence, and remedied, so far as we now know, only by substituting some other crop for a number of years. Stock peas are being sown quite extensively and are meeting with increasing favor as a forage crop. It is believed that alfalfa might profitably be added to the grass crops raised on this soil, and it is hoped that careful and thorough experiments with this may be made.

All the common fruits do well, though none are grown for the outside market. Peaches would do well on the shaly slopes in the southern portion of the area, and if entered upon on a sufficiently large

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scale to render marketing economical the industry might be introduced with profit.

The following table shows the texture of typical samples of the soil and subsoil of this type:

Mechanical analyses of Miami silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6869	1 mile E. of Morganfield.	Silt, 0 to 9 inches...	1.18	0.18	0.42	0.28	0.66	7.62	82.86	7.42
6529	½ mile E. of Morganfield.	Silt, 0 to 11 inches..	1.39	.00	.12	.23	.59	9.70	81.30	8.00
6871	1 mile E. of Uniontown.	Silty loam, 0 to 10 inches.	1.09	Tr.	.30	.24	.52	6.08	81.38	11.16
6530	Subsoil of 6529......	Silt, 11 to 36 inches.	.39	.00	.23	.31	.62	5.77	76.90	16.60
6872	Subsoil of 6871......	Silty clay, 10 to 36 inches.	.42	Tr.	.14	.46	.38	4.68	72.88	20.68
6870	Subsoil of 6869......	Silty loam, 9 to 36 inches.	.42	.06	.40	.30	.64	6.98	67.52	23.70

WAVERLY SILT LOAM.

The Waverly silt loam, which is designated by the farmers as "black bottom," is found in all parts of the upland division of Union County. The principal areas are found on the southeastern border of the area, occupying the level country lying southward from the Pond Fork, and in the eastern section along the broad, level bottoms of Highland and Caseys creeks. In texture the soil is eminently adapted to agriculture. It is a dark, almost black, silt loam, plastic like a clay loam when wet, but mellow and loamy when dry. The soil, which varies little to a depth of 12 to 15 inches, is underlain by a plastic black or drab clay loam. A profile generally shows, at from 3 to 5 feet below the surface, a yellowish silt loam which closely resembles in character the subsoil of Miami silt loam and is probably of the same material.

The physiography and physical character of the soil suggest its origin to be a combination of shallow-water deposition and marsh accumulation. It is said that much of this land, now well drained and free from overflow, was once covered with shallow, nearly stagnant water for a greater part of the year. It was thickly forested, however, and falling leaves and decaying vegetable matter were mixed with the sediments brought down by the rain waters. It is probable that this soil originally occupied all the stream bottoms, for it is usual to find it underlying other bottom soils, as though these had been recently washed on.

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This soil is liable to be wet unless underdrainage is practiced. Much of it is underdrained, though where the bottom is narrow it is often sufficient simply to deepen and straighten the stream course. A good quality of tile, manufactured within the county, is easily available, and land can be tile-drained at a net cost of 55 to 80 cents per rod, the price varying according to size of tile used.

Practically all the crops grown within the area do well on this type of soil. Corn averages nearly 60 bushels per acre and occasionally produces as high as 75 or 80 bushels. It is also eminently adapted to grass; both clover and timothy give good yields. Wheat in favorable seasons will make 25 to 30 bushels per acre, with an average yield of 20 bushels, but the quality of the wheat is not so good, as a rule, as that raised on the Miami silt loam. The straw is very heavy and liable to lodge. Tobacco yields are heavy, 1,300 pounds per acre being a fair estimate of the average; but this, too, is not always of the best quality, and the larger yield is counterbalanced by the lower price which it brings in the market. On the whole, the soil is best adapted to the raising of corn and grass.

Mechanical analyses of the soil and subsoil of this type are given in the following table:

Mechanical analyses of Waverly silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6531	1 mile N. of Seven Guns.	Silty loam, 0 to 14 inches.	1.28	0.00	0.25	0.14	1.21	9.37	85.50	3.48
6879	4 miles NE. of Morganfield.	Loam, 0 to 10 inches.	2.93	.32	.16	.18	.60	2.10	92.54	3.58
6877	3 miles NE. of Waverly.	Silty loam, 0 to 12 inches.	2.57	.36	.46	.30	.50	6.00	80.48	11.50
6532	Subsoil of 6531	Silty loam, 14 to 36 inches.	.94	.27	.31	.41	1.68	5.53	84.75	7.05
6878	Subsoil of 6877	Silty loam, 12 to 36 inches.	1.22	.36	.70	.32	.36	5.90	84.52	7.42
6880	Subsoil of 6879	Clay loam, 10 to 36 inches.	1.20	.56	.70	.26	.40	1.66	87.56	8.44

SHARKEY CLAY.

Sharkey clay is a soil of comparatively limited extent. The principal areas of it lie in the southeast, in what is known as the Pond Fork district along the North Fork of the Tradewater River. Other small areas are found in the southwest, near Henshaw, and there are a few narrow strips of it occurring in the Ohio River bottoms.

This soil, sometimes called "gumbo land," is a heavy drab or dark-

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brown clay, impervious and very difficult to work. It bakes hard in the sun and when plowed up wet forms compact clods which crumble and fall to pieces like quicklime when the rain falls on them. The coarse, granular structure produced by this "slaking" gives rise to the term "buckshot land," which is often used to designate this condition of the soil. The soil is about 6 inches deep and is underlain by a stiff, waxy clay subsoil, usually of a dark bluish-gray color or mottled.

The principal areas of Sharkey clay are found along the level bottoms of the stream courses. Little of it is under cultivation. It is generally wet and in need of drainage, being subject to overflow. Most of the areas of Sharkey clay are covered by a dense growth of timber, but some portions of newly cleared land were met with where corn was being grown, and good yields of this crop are reported. At first it is very difficult to turn this soil, even with a steel plow drawn by 3 or 4 horses, but after a few years of cultivation, especially when the land has been drained by ditching and tiling, the soil becomes quite mellow and loamy, very closely resembling, if not identical with, the Waverly silt loam. Indeed, much of the soil mapped as Waverly silt loam was originally in the condition of the Sharkey clay, but has been so changed in character through a long period of cultivation and drainage that it is now recognized as a distinct type with widely differing properties. Thus the expenditure of labor and money in the improvement of these lands will bring a sure return in a soil of lasting fertility.

It is probable that this soil was accumulated as a sediment deposited in shallow water when the low-lying portions of the country were covered with boggy lakes. That it has been subjected to swamp conditions is evidenced by its dark color and the comparatively large percentage of organic matter which it contains.

The following table gives the results of mechanical analyses of soil and subsoil of this type:

Mechanical analyses of Sharkey clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6623	3 miles E. of Sturgis.	Clay loam, 0 to 6 inches.	5.77	0.34	0.70	0.54	2.20	4.60	55.64	35.64
6624	Subsoil of 6623......	Waxy clay, 6 to 36 inches.	1.35	.10	.50	.38	1.74	5.00	60.00	32.18

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STURGIS FINE SANDY LOAM.

The only sandy soil in the upland section of the area is the Sturgis fine sandy loam. The soil to a depth of 12 inches is a fine sandy loam, brown or reddish in color, and composed of a mixture of fine sand and silt. In a few limited areas this varies to a medium sandy loam composed almost entirely of sand. The subsoil is a sticky, yellowish, fine sandy loam grading into a heavy, tenacious silt very similar to the subsoil of the Miami silt loam. This silt subsoil is met at a depth varying from 2 to 4 feet and appears to be the original surface soil upon which a layer of sandy sediment has been deposited. This type of soil is found only in comparatively limited areas. It occurs in a belt a mile or two wide along Cypress Creek in the southern portion of the county. The surface is level or gently undulating.

As stated before, this soil stands alone of all the upland soils in being of a distinctly sandy nature, so the question of its origin is not quite clear. The process of its formation was probably one of deposition by flowing waters. At an earlier stage in its development Cypress Creek probably overflowed its banks at times of heavy floods and spread out over the level valley through which it flows. The water, carrying with it particles of sand and silt in suspension, deposited these when the widened course of the stream allowed the water to flow more slowly, and the coarser particles were laid down first near the banks. The grading from coarser to finer material in the soil from the present bank of the stream outward supports this view.

The Sturgis fine sandy loam is a well-drained soil, but because of its more open texture it is more likely to suffer from drought than the other upland soils. This is especially true on the ridges, where the soil contains a smaller admixture of silt.

The crops at present grown are those general throughout the area—corn, wheat, and grass. Corn produces from 25 to 35 bushels and wheat an average of 15 bushels per acre. It is not as good land for grass as the heavier bottom lands, but it is thought that alfalfa might be more successfully grown than either clover or timothy, while the more sandy ridges are perhaps better adapted to the production of watermelons than to the crops at present cultivated. However, the total area occupied by this type is not large enough to make it of much importance.

The table on the next page shows the texture of the soil and subsoil of this type.

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Mechanical analyses of Sturgis fine sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6625	1 mile S. of Sturgis.	Fine sandy loam, 0 to 12 inches.	0.64	0.00	0.10	0.20	39.34	27.50	24.96	7.40
6626	Subsoil of 6625.....	Silt and sand, 12 to 36 inches.	.21	.00	.14	.20	30.42	27.82	24.28	16.96

YAZOO CLAY.

The Yazoo clay is the principal river bottom soil. It covers an area of about 38 square miles, stretching in an unbroken belt along the Ohio River from the northernmost extremity of the county to the Tradewater River, which forms its southern boundary. About half the area of this soil is at present under cultivation, the remainder being for the most part heavily timbered. It is separated from the upland by the "bluff" or "river hills," while a narrow strip of Miami fine sandy loam is usually found between it and the river banks.

Its color is of a dark-brown or tan-bark shade. There is little apparent difference between soil and subsoil, except where cultivation has influenced the physical character of the surface. It varies considerably in condition and somewhat in texture in different parts of the area. Near the bluff, where it is usually covered with timber, it is more apt to be wet and marshy. This gives it the appearance of being very heavy and tough, but under cultivation it becomes more friable, though somewhat hard to work and liable to clod and bake. Toward the river it often becomes considerably lighter through an admixture of sand. This phase, which is a stage in the gradation from the clay to the sandy loam, is considered very desirable, as it is more easily cultivated.

This soil is an alluvial deposit belonging to a recent geological period. In fact, inasmuch of the area is subject to occasional overflows that add their part to the thickness of the alluvium, it may be considered as still in process of formation. It is a strong, fertile soil capable of producing good yields of various crops. On account of the danger from overflow, however, it is planted almost exclusively to corn. For the most part the land is owned or rented by farmers having farms in the upland district, who remain on the bottoms only long enough to cultivate and harvest this crop. In places quite extensive areas of Yazoo clay occupy a higher terrace or "second bottom," where crops are practically safe from damage by high water in the spring. On such

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areas wheat and other crops are planted and do remarkably well. Oats, hay, and tobacco are among those reported to yield high averages on this soil. The average yield for corn is 45 bushels per acre, with occasionally a crop of 60 to 75 bushels in favorable seasons.

The mechanical analyses of typical samples of the Yazoo clay are shown in the following table:

Mechanical analyses of Yazoo clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6883	5 miles W. of Uniontown.	Clay loam, 0 to 10 inches.	2.65	0.10	0.12	0.28	0.76	1.64	66.60	29.82
6881	Near Raleigh	do	3.18	.16	.28	.30	1.24	6.58	59.94	31.50
6884	Subsoil of 6883	Clay loam, 10 to 36 inches.	1.62	Tr.	.04	.02	.46	18.52	59.74	21.68
6882	Subsoil of 6881	do	1.48	Tr.	.28	.28	2.28	11.06	49.62	36.00

MEMPHIS SILT LOAM.

The Memphis silt loam is a stream-bottom type, locally known as the "gray bottom" or "made land." The soil is a brown or yellowish-gray silt loam 12 inches or more in depth, underlain by an incoherent silt of a mealy texture. It differs in texture from the other silt soils of the area in being in no degree plastic or tenacious, but rather of the character of a very fine sand. As a rule it varies but little in texture to a depth of 3 or 4 feet, although the upper foot is usually of a more loamy nature, due to the effects of cultivation.

This soil is found throughout the whole upland portion of the area, where it lies in narrow strips along the edges of the streams. It is colluvial in origin, formed by the deposition of soil washed from the surface of the Miami silt loam. It is probable that a good deal of this type is of recent formation, having been formed since the land was settled, and it may owe its origin largely to the hand of man. It is generally underlain at a depth of from 2 to 4 feet by the heavy black soil of the Waverly silt loam, upon which it has been deposited. This heavy loam originally covered most of the upland valleys, but when the country was cleared of its protection of timber and put under the plow the rain waters drained off more rapidly, flooding the narrower stream bottoms and carrying along a large amount of the surface soil from the upland to be deposited in these bottoms. In those broader bottoms where the Waverly silt loam is the predominating type—as, for instance, in the Highland Creek bottom, on the eastern border of the

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county—there is usually found a belt of the Memphis silt loam on each side of the stream, where repeated overflows have left a covering of this deposit over the original black soil.

The soil is apt to be wet and "crawfishy" unless it is underdrained. It is not a difficult soil to drain. Most of that under cultivation is tiled, the tile lines being led into the main stream, which is usually deepened and straightened. This not only provides an outlet for the tile lines, but also enables the stream the better to carry off the water at times of heavy rainfall, and so prevents overflow.

The crops chiefly grown are corn, wheat, and hay. The type is best adapted to corn, yielding an average of 40 bushels per acre, while yields of 50 or 60 bushels are often produced. Grass also does very well, but the soil is not as well adapted to the production of wheat. Some tobacco is grown, but it is liable to suffer from "frenching," and the soil is not thought to be as favorable for this crop as the upland types.

The following table shows the texture of the soil and subsoil of this type:

Mechanical analyses of Memphis silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6873	Near Morganfield..	Silt, 0 to 12 inches..	1.06	Tr.	0.34	0.14	0.98	8.74	82.78	6.04
6875	2 miles S. of Morganfield.	.....do...............	1.09	.40	.44	.28	.80	3.40	83.06	11.52
6874	Subsoil of 6873......	Silt, 12 to 36 inches.	.46	Tr.	.06	.16	2.04	11.08	78.14	7.76
6876	Subsoil of 6875......	.....do...............	1.84	.20	.56	.78	6.04	9.20	75.02	7.88

MIAMI FINE SANDY LOAM.

Miami fine sandy loam is the name given to the least important of the river-bottom soils. It is a red-brown or yellowish sandy loam of medium texture, but varies considerably in the percentage of clay it contains. A typical profile shows the mellow sandy loam 10 inches in depth overlying red sand. Sometimes clay loam is met at a depth varying from 1 to 4 feet. Often the soil is a loose, incoherent sand, resembling beach sand, and this phase is sometimes devoid of vegetation. The soil occurs in low ridges, usually very narrow, immediately bordering upon the Ohio River. The areas of this type are, as a rule, higher than the Yazoo clay which lies adjacent to them. These sands are the product of alluvial deposits laid down during the inundations which frequently occur. As long as the swollen stream is con-

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fined within its narrow channel the flow is so swift that the coarse particles are held in suspension, but as soon as the overflow takes place and the water, spreading out over the broad, level bottoms, is retarded in its rate of flow, the sediment is dropped, the sand being the first to be laid down. Farther from the banks, where the flow is still more sluggish, silt and clay particles are deposited, forming the clay loam soils.

Nearly all of this soil is under cultivation, though there are some local areas of nearly pure sand upon which no crops are grown. Corn is the principal crop, and where there is a considerable proportion of clay in the soil an average yield of 40 to 45 bushels per acre is secured. Watermelons are also grown, and many small patches too sandy for other crops produce excellent melons. The soil is eminently adapted to the growing of garden vegetables and has the added advantage of being located close to the river, affording easy transportation facilities. It would seem that a trucking interest might profitably be started here.

The following table gives mechanical analyses of soil and subsoil of this type.

Mechanical analyses of Miami fine sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6885	6 miles NE. of Uniontown.	Fine sandy loam, 0 to 10 inches.	1.25	Tr.	0.30	0.12	14.88	47.38	22.58	14.02
6886	Subsoil of 6885	Medium sand, 10 to 36 inches.	.89	Tr.	.14	.16	46.24	41.50	6.26	5.02

AGRICULTURAL CONDITIONS.

Union County is distinctly an agricultural community. The degree of prosperity among the farming classes is above the average for the country at large. The fertility of the soils, together with the thrift of the owners, has made the farmer of this community a prosperous man and has brought within his reach the comforts and many of the luxuries of life.

As a rule the farms are worked by the owners, though renting on shares or for a stipulated money rental is not uncommon. The farms are generally small, ranging from 75 to 200 or 300 acres, with an average of about 100 acres.

The agricultural pursuits of the county are quite diversified, and no one product can be spoken of as the chief interest of the community.

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Wheat, corn, tobacco, and hay are extensively grown, and all yield good returns. Although one farmer or one district may produce one of these practically to the exclusion of the others, still the rule is to vary the crops and practice a system of rotation. The most usual succession is wheat followed by clover, which, after being allowed to stand as pasture or meadow for two or three years, is followed by corn.

It is a country where anything like a total failure of crops is unheard of, even when there is a great shortage in other sections. The soil, which is naturally strong and fertile, is kept up by the growing of clover and other favorable crops and by the practice of proper cultural methods. Considerable stock is kept on all the farms. The production of large quantities of corn, wheat, and tobacco, which require horse cultivation, naturally leads to the keeping of a good many horses and mules. The raising of cattle and hogs is an industry of large and increasing importance. All these things have an important bearing on soil problems, for where stock is fed on the farm and the products of the soil are returned to it in a large measure as barnyard manure there is much less danger of exhausting the native fertility of the land.

In connection with the keeping of stock, some suggestions might be made as to possible improvements. In the first place, the barns and stables are, as a rule, poorly constructed, as is too often the case where the climate is mild. Where cattle must be housed through the winter these structures do not furnish adequate shelter during the few weeks of severe weather. The barns, which are without foundations, have no floors, and the stable manure is allowed to accumulate in the stalls for weeks and months at a time, instead of being thrown out into compost piles. Large stacks of wheat straw are annually burned in the field, merely to get rid of them. It would be well to utilize this large quantity of organic fertilizer; for though it may contain little real plant food, still if it were used for bedding stock and incorporated with the stable manure, or allowed to decay in piles and then applied to the land, it would be of great benefit in adding humus and improving the tilth of the soil. Such treatment is greatly needed by the soils in some of the hilly sections, where washing is liable to occur.

Permanent pastures are few, and it is thought that a change for the better might be made in this respect. The rule now is to pasture clover fields the second year, and sometimes the first year, while stock is often grazed on the young wheat in early spring. Blue grass does remarkably well, and in the few cases where permanent pastures have been sown to it they have given very satisfactory results. In those regions that now suffer serious erosion on account of the cultivation of grain and tobacco permanent pastures would be particularly serviceable in checking such deterioration of the land.

Fruit is found throughout the whole county, and many varieties do unusually well. Little or none is raised for the foreign market, but

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each farm has a small orchard near the house which supplies the domestic need. Apples, peaches, and plums, with grapes and some small fruits, are the kinds chiefly grown. Conditions seem especially well adapted to apples, and in the eastern section near the Henderson County line there are several small, well-kept orchards that yield good returns. Several winter varieties are successfully grown and can be shipped with profit to outside markets.

Much of the bottom lands throughout the county, which were originally wet and unfit for crop production, have been reclaimed by thorough systems of drainage. There are large areas still remaining which when thus improved will develop into most productive farms. The usual method of drainage in the small stream bottoms is to deepen and straighten the stream bed to carry off the surplus water and prevent overflow at times of heavy rains. Where the bottom is narrow this may suffice, but generally lines of tile are laid laterally, leading into the central ditch. Through several of the broader bottoms an outlet ditch is constructed by the county. The community desiring an outlet drain petitions the county court; and if the petition is granted, the construction is carried on under the supervision of county officers, and a tax is levied upon the property benefited. Little or no drainage has been practiced on the Ohio River bottoms, but there is a good deal of marshy land there that might be rendered valuable by proper methods of drainage.

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SOIL SURVEY OF POSEY COUNTY, INDIANA.

By HERBERT W. MAREAN.

LOCATION AND BOUNDARIES OF THE AREA.

Posey County is situated in the extreme southwestern corner of the State of Indiana. It is bounded on the south by the Ohio River, on the east by Vanderburg County, on the north by Gibson County, and

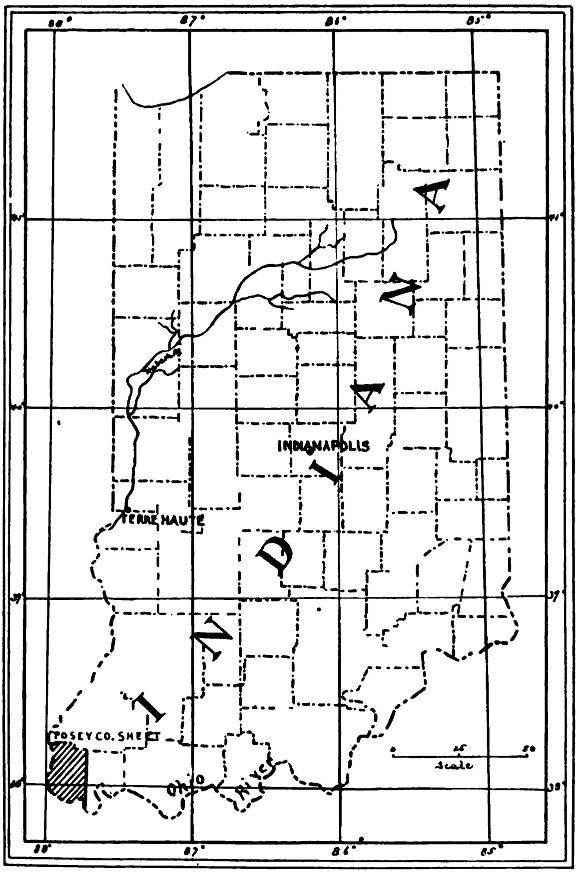

Fig. 12.—Sketch map showing area surveyed in Indiana.

along its entire western border flows the Wabash River. The county has a population of about 23,000, composed mostly of whites, though there is a small colored population along the southern boundary. Mount Vernon, the county seat, is situated in the middle southern part of the county, on the Ohio River. It has a population of about 5,000.

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New Harmony and Poseyville rank next in size and importance. Good transportation facilities are afforded by the three lines of railroad which cross the county, while the Ohio River furnishes easy means of traffic by water. (See fig. 12.)

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Little is known of the conditions existing in this part of the country previously to the advent of the white settlers. There are evidences, however, that point to the fact that the territory was held by the Potawatomi and Wea Indians. The first settlers came from North Carolina and Tennessee in the year 1809. A number of German families from Pennsylvania also settled in the county, and to-day the German element constitutes a thrifty and prosperous community in the eastern part of the county. These pioneer farmers established their homes on the sand hills and ridges, where springs afforded an adequate supply of water, above the unhealthful influences of the swampy lowlands. Agriculture at this early day was necessarily primitive and conducted upon a small scale. A few acres of cleared land sufficed for the needs of the family, and rude log huts were their dwellings. Crude implements were employed in the cultivation of meager crops of corn and wheat. These were the principal products, with small quantities of cotton and hemp which served to furnish their clothing. Some of the best lands of the county were then in a swampy condition and have more recently been developed by improved methods of drainage. Conditions gradually improved, and through a recognition of the fertility of the soil and the advantages derived from reclaiming swamp lands, agriculture in the county was given an impetus which has lasted to the present time, and to-day Posey County is one of the richest farming districts in Indiana. At least two-thirds of the county has been cleared and put under cultivation since 1860. Prominent among those who took an active part in the development of the county and the administration of its affairs were the Rapps, the Owens, and Thomas Posey. The last mentioned was governor of the Territory of Indiana previously to its admission as a State, and Posey County was named in his honor. The county was organized in September, 1814, when, by an act of the legislature, Posey County was formed from parts of Gibson and Warrick counties. In December, 1818, Vanderburg was formed from parts of Gibson, Warrick, and Posey, when the present boundaries of the county were permanently fixed.

CLIMATE.

Mount Vernon, situated on the Ohio River, is the only station of the Weather Bureau in Posey County, but the records of temperature and rainfall kept by that station are quite fragmentary and no normals have been established. The nearest stations outside the county for which normals have been established are Evansville, situated on the

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Ohio River and in about the same latitude as Mount Vernon, though 20 miles farther east, and Princeton, the county seat of Gibson County—the next county to Posey on the north—and about 15 miles north of the county line. The table given below contains data drawn from the records of these two stations. It is believed that they fairly represent the conditions of the area surveyed.

Normal monthly and annual temperature and precipitation.

Month.	Evansville.		Princeton.	
	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	Inches.	° F.	Inches.
January	35.4	3.41	30.7	2.96
February	32.3	2.98	32.9	3.23
March	44.6	4.84	42.3	4.33
April	57.0	3.55	54.7	3.37
May	67.0	4.38	64.1	3.67
June	76.3	4.67	74.6	4.35
July	79.6	3.54	76.9	2.83
August	78.4	2.09	75.1	2.64
September	71.9	2.48	68.2	3.16
October	59.2	2.87	55.4	2.16
November	45.0	3.67	42.9	3.82
December	35.8	3.02	35.3	3.15
Year	56.8	41.50	54.4	39.67

The frost records kept by the station at Mount Vernon are more complete. The occurrences of the last killing frost in spring and first in fall during the last nine years are given in the following table:

Dates of killing frosts.

Year.	Mount Vernon.		Year.	Mount Vernon.	
	Last in spring.	First in fall.		Last in spring.	First in fall.
1893	Mar. 29	Oct. 29	1899	Apr. 10	Sept. 27
1894	May 19		1900	Apr. 12	Nov. 8
1895	May 14	Oct. 1	1901	Apr. 21	Oct. 17
1896	Apr. 4	Oct. 19	Average date	Apr. 17	Oct. 20
1897	Apr. 20	Oct. 29			
1898	Apr. 7	Oct. 27			

From the above table it appears that, at least along the Ohio River, there is an average period of one hundred and eighty-six days during which tender vegetation is safe from damage by freezing. This period is probably subject to local variation, due to differences of elevation or other physiographic features.

PHYSIOGRAPHY AND GEOLOGY.

Posey County lies in the point between the Ohio and Wabash rivers at their confluence, and these streams form the natural boundaries of the county, as well as of the State, on the south and west. The flood

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plains of these two rivers form together one of the two main physical divisions into which the county naturally divides itself. The width of the river bottoms varies from a few rods to 4 or 5 miles. The topography of these bottoms is generally level; sometimes very gently undulating, with depressions or sloughs alternating with low ridges that are apt to be sandy in nature. Two or three low but distinct terraces can be observed in crossing from the banks of the stream to the bluff which separates the river bottoms from the upland. These terraces mark successive stages in the erosion of the river valley, and a change of soil type is likely to be encountered as one passes from a lower to a higher flood plain. Thus in Point Township the lower plain along the Ohio and Wabash rivers is occupied by the Yazoo clay, while in ascending a bluff 10 or 15 feet high we come upon the Guthrie clay, occupying an older flood plain formed by the combined action of the two rivers. So also in the region east of Mount Vernon the lower bottom is occupied by recent sediments, while rising 25 feet above this is a level area which is now covered by Waverly silt loam, but which was once formed as an alluvial plain of the Ohio. The original soil of this older bottom can be seen in deep stream cuts underlying the deposit of loess, from which, by weathering, the present soil has been derived.

The rise from the river bottoms to the uplands varies greatly in abruptness. Along the Wabash, especially where the bottom is narrow, the ascent takes the character of a steep bluff, rising in some instances to an altitude of 150 feet above the river. In the south, however, along the Ohio River, the slope from the bottoms to the upland is more gradual. Again, in the eastern border of the county a bold bluff separates the two physiographic features of the county.

The general character of the surface in the upland may be described as undulating. Low, rolling hills, descending with symmetrical curves to the broad stream valleys, with here and there a wooded slope, combine to form a scene most pleasing to the eye. The general slope of the country is toward the southwest. A large part of the upland is drained by Big Creek and its tributaries, emptying into the Wabash west of Upton. The Black River drains a narrow belt on the north, and in its lower course, where it joins with the broad Wabash Valley, it has cut off a portion of the upland which rises in an isolated mesa-like plateau 50 or 75 feet above the surrounding valley. A few minor streams in the south empty directly into the Ohio River.

Underlying the soils of the whole county are found rocks belonging to the Carboniferous or coal-bearing group. These rocks, which are usually shales or shaly sandstones, are met at an average depth of 20 feet. Deep road cuts sometimes reveal the disintegrating shale with loess lying unconformably above it. Along the river bluffs, near the eastern border of the county, outcrops of an impure limestone are to

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be found. Inasmuch as all these rocks are covered by a deep coating, either of loess or river sediment, they have had no direct influence upon the formation of the soils. But there is an intimate relation between the soils of the county and Pleistocene geology. The invasion of the ice sheet which took place in the beginning of the Quaternary era reached to the southern part of Indiana, and traces of it are to be found in the northwestern corner of Posey County. Wells dug in the neighborhood of Poseyville pass through a stratum of granitic gravel which is unmistakably of glacial origin, and in other places in Robb and Harmony townships glacial till underlies the deposit of loess. Evidences of glacial action are also to be seen in the physiography of this section. The level-topped plateau previously mentioned, which lies just north of Griffin, is plainly a "glacial bench" formed by the glacier as it passed over this hill and planed off the overlying softer beds, leaving the nearly level surface of the harder strata to form an isolated table-land. Throughout the valley of the Black River, and to a less extent in the Wabash bottom, granitic and other crystalline gravels are found, indicating that these recent sediments may be composed largely of reworked glacial material.

SOILS.

The soils of Posey County present many interesting problems to the student of agriculture. Though not differing greatly in native fertility, they show an unusual degree of variation in their physical properties. In a limited area are to be found five or six distinct types and phases of soil, each with its own peculiar relation to the quality and quantity of crops.

The soils naturally divide themselves, according to the two main physiographic features, into the upland types and the river-bottom types. There are four upland types: Miami silt loam, Waverly silt loam, Miami sand, and Memphis silt loam. The river-bottom types, including soils occurring on the level flood plains of the Ohio, Wabash, and Black rivers, are seven in number: Yazoo clay, Guthrie clay, Yazoo loam, Miami fine sandy loam, Yazoo sandy loam, Miami sandy loam, and Griffin clay.

The following table shows the extent of each of the several soil types:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami silt loam	149,376	60.3	Miami sand	7,680	3.1
Yazoo clay	30,720	12.4	Miami sandy loam	3,584	1.4
Waverly silt loam	16,384	6.6	Miami fine sandy loam	3,456	1.4
Guthrie clay	14,592	5.9	Yazoo sandy loam	2,752	1.1
Memphis silt loam	9,408	3.8	Griffin clay	1,600	.6
Yazoo loam	8,320	3.4	Total	247,872	

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MIAMI SILT LOAM.

This is a soil of remarkable uniformity. Over the large area which it covers it maintains a nearly constant character with only minor variations due to the physical features of the land. The soil is typical of a silt loam. Fine sand is present to a considerable degree, but the percentage of coarse sand and clay is very small. When wet it possesses a certain degree of plasticity, but when dry it is open and friable, crumbling into a loamy mass under cultivation. The surface soil is light gray or reddish yellow. The more open portion of the soil, which constitutes the soil proper, extends to a depth of about 9 inches. Lying below this is found a more plastic silt loam of a light-red or yellow color, and this is in turn underlain at 14 or 15 inches by rather heavy, tenacious silt loam of a claylike nature. This heavier subsoil contains more clay particles and less of the fine sand groups, but, as will be seen by the accompanying mechanical analyses, silt still predominates. The subsoil in some cases descends with little variation to a depth of 10 or 20 feet, but as a rule deep cuts reveal a change occurring at about 5 feet below the surface. At this depth the red claylike material grades into an incoherent yellow silt, which in some cases shows traces of stratification.

The Miami silt loam is by far the most extensive soil in Posey County, covering more than half the total area. It is found in every part of the upland region, where it occupies all the various features of topography. In general, however, the country over which it extends presents a moderately rolling surface. Little or none can be called rough or broken, although along the eastern border the aspect of the country approaches this condition. In some localities the soil lies almost perfectly level, and here is found a phase varying somewhat from the type. The surface is light gray, and mixed with the soil are small nodules of concretionary iron oxide. The soil in these places is deeper than on the ridges, and the subsoil is generally lighter in shade, indicating a lower degree of oxidation of the iron salts.

In the southwestern part of the county, where this type borders the Guthrie clay, and also in the region west of Mount Vernon, a phase of the Miami silt loam is found which is deserving of attention. The soil here is rather mixed; small, sandy patches are found occupying low ridges or knolls, and where they are sufficiently extensive are indicated on the soil map as areas of another type. Other patches are found occupying little depressions, and here the soil is of a whitish color with a mottled claylike subsoil. The phase has arisen as a result of wet conditions that have prevailed, consequent upon the low-lying, level position of the soil.

The origin of the Miami silt loam explains its uniformity of character and its wide distribution. It is composed of material known to geologists as loess. This material is supposed to be of glacial origin, brought down by the ice sheet in the great Ice Age of North America.

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Though there is little difference of opinion as to its origin, the manner in which it was deposited is still a matter of controversy. Some believe it to have been deposited in the shallow waters of a great inland sea, which they suppose to have covered a vast area in the Mississippi Valley at that period. Others think the deposits should be attributed to æolian agencies; that the winds blowing across the ice covered with earthy débris and over the deposits of till, unprotected by vegetation, bore away the finer particles of dust and dropped them over the region farther south.

It is easy to see that a soil derived from so wide a source will possess much of the natural fertility that we find in alluvial soils. It is not apt to lack any of the essential ingredients of plant food, and in its physical properties it will be well adapted to widely varying agricultural products. Such is the case with the Miami silt loam. Wherever found it is a fertile soil, producing good yields of wheat, corn, and clover, and timothy hay—the staple products—together with some fruit and garden vegetables that are raised for home use. The average yield of wheat is 20 bushels per acre and of corn 35 or 40 bushels, while in favorable seasons 25 or 30 bushels of wheat and 50 bushels of corn are produced per acre. Some strawberries and other small fruits are grown in the vicinity of the larger towns and yield good returns. A number of Kieffer pear orchards are found on this soil, but apples seem to be the fruit best of all suited to the soil and climatic conditions. (See Pl. XXV.)

The following table gives mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Miami silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7122	3 miles W. of Mount Vernon.	Silty loam, 0 to 8 inches.	1.49	0.00	0.44	0.40	0.78	3.76	85.20	8.62
7120	1 mile N. of Mount Vernon.	Coarse silty loam, 0 to 8 inches.	2.47	.00	.14	.08	.36	3.86	81.82	13.68
7124	7 miles E. of Mount Vernon.	Silty loam, 0 to 7 inches.	1.90	.56	2.10	1.56	4.30	10.90	62.28	17.36
7121	Subsoil of 7120	Heavy silty loam, 8 to 36 inches.	.34	.00	.10	.12	.50	5.92	84.16	9.10
7123	Subsoil of 7122	do	.49	Tr.	.32	.18	.42	5.78	70.34	22.26
7125	Subsoil of 7124	Heavy silty loam, 7 to 36 inches.	.47	.30	1.58	1.12	2.46	6.20	54.68	33.30

WAVERLY SILT LOAM.

The Waverly silt loam is the soil locally known as the "black bottoms." The soil is a mellow, black loam, plastic when wet but loamy

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and easily tilled. It becomes heavier at a depth of 7 or 8 inches, and the black loam is underlain at a depth of from 10 to 20 inches by a yellowish or drab clay loam, plastic and tenacious. This subsoil contains more silt than true clay, but it possesses the characteristics of a clay loam. The black color of the soil is due to the presence of organic matter, which also gives the soil a very desirable tilth when cultivated. In some instances there is little change in the appearance of the soil to a depth of 20 inches or more.

The total area of Waverly silt loam is comparatively small, but it ranks third in agricultural importance. It covers in all about 25.6 square miles, or 16,384 acres. It occurs in nearly all parts of the county, but the principal areas occur in the neighborhood of Poseyville, at the northern border of the county, and in the vicinity of Mount Vernon in the south. Small, scattering areas occur throughout the upland region, and there are a few patches along the bottoms of the Wabash and Black rivers. In the Poseyville and Mount Vernon areas, where it is most typically developed, the soil occupies level or gently sloping topography. Along the Wabash bottoms it is sometimes found as a gently sloping talus at the foot of the river bluffs, and here it is more sandy than the typical soil. In other localities it occurs in minor depressions, where the poor drainage has given rise to marshy conditions and allowed considerable amounts of humus to accumulate. A small area in the valley of the Black River differs from the type in being of a heavier and more claylike character. This phase possesses a very heavy, tenacious, drab clay subsoil and is commonly characterized by a slight admixture of coarse sand and rounded gravel in the soil.

There is an intimate relation between the origin, physiography, and drainage of the Waverly silt loam. With the possible exception of the small area found in the Black River Valley, which may be in part alluvial, the soil is of loess material. In the Poseyville area it lies in the broad, level upland valleys that resemble old lake floors. The material forming the mineral portion of the soil was deposited at the same time and probably in the same manner as the loess of the surrounding uplands. But the low-lying areas, now occupied by the black soil, were covered by shallow, stagnant water, or by bogs and swamps, and fallen limbs and leaves of trees and decaying swamp vegetation added to the soil the supply of humus which gives it the black color and loamy tilth which it now possesses. Silt was also sifted in by washing from the uplands while this swampy condition prevailed, for the organic matter did not accumulate as a layer of peat, but was thoroughly mixed with soil particles. Subsequently, through natural process of erosion and by artificial means, these lands have been drained and to-day form one of the most highly valued soils of the area.

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Considerable ditching and tile drainage is practiced in areas of this soil, and always with good results.

In the southern part of the area, east of Mount Vernon, the soil also occupies a level position. Here it lies upon an old Ohio River terrace, where a coating of loess covers the clay loam of the ancient river flood plain to a depth of 20 feet or more. The southern boundary of this area is a bluff with a descent of 25 to 30 feet to the present river bottom. As there is no barrier which might have held back the surface water from draining into the Ohio River, the imperfect drainage which produced marshy conditions must have been due to level topography and the texture of the soil. Upon this old terrace the soil grades by degrees into the Miami silt loam, and no sharply defined boundary between the two types is found.

In agricultural importance the Waverly silt loam stands next to the Yazoo clay. It is well adapted to all the crops now grown in the county. The average yield of corn is 50 bushels per acre; of wheat, 25 bushels; while clover crops yielding from 1½ to 2 tons of hay per acre are cut, with a second cutting for seed. Some fruit and vegetables are grown, but only on a limited scale and for home consumption. The soil is well adapted to the production of timothy hay, and yields of from 1 ton to 1½ tons per acre are average crops.

The texture of this soil is shown by the mechanical analyses given in the following table:

Mechanical analyses of Waverly silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7132	2 miles E. of Mount Vernon.	Silty loam, 0 to 10 inches.	3.56	0.10	0.44	0.24	2.10	10.68	74.78	11.48
7134	4 miles E. of Mount Vernon.	Loam, 0 to 12 inches.	2.77	.20	.50	.24	1.14	5.78	78.44	13.68
7133	Subsoil of 7132......	Sticky silty loam, 10 to 36 inches.	1.61	.12	.52	1.00	4.18	8.56	71.28	14.30
7135	Subsoil of 7134......	Clay loam, 12 to 36 inches.	1.35	.40	.60	.30	.88	4.98	78.38	14.36

MEMPHIS SILT LOAM.

The Memphis silt loam is an upland type, sometimes called the "gray bottom," or made land. The soil is a brown or yellowish-gray silt loam 10 or 12 inches in depth, underlain by silt of a mealy texture. It differs in texture from the other silt soils of the area in that it lacks the plasticity that they usually possess, resembling in this respect very fine

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sand. As a rule, the soil varies but little in texture to a depth of 3 or 4 feet, although the upper foot is usually of a more loamy nature, due to the effects of cultivation.

This soil is found occupying the narrower stream valleys in the upland portion of Posey County. No large areas of it occur, but it extends in narrow strips, from 200 to 500 yards wide, along the edges of the upland streams. The most extensive of these belts is that along the Big Creek bottoms in the eastern part of the county. Other narrower belts are found throughout the territory occupied by Miami silt loam, and occasionally these extend for a short distance into the river lowlands.

The soil lies in a nearly level position, forming the flood plain of the stream to whose agency it owes its origin. These flood plains are subject to frequent overflow, and the land is generally inclined to be wet and in need of drainage. Where the bottom is narrow, a common method of drainage is employed in which the stream channel is deepened and straightened. If the flood plain is broader, a more adequate method is to lead lateral lines of tile into this central ditch.

As we should expect, this soil, derived by stream sedimentation from fertile upland soils, is a strong and productive type. Corn is the crop chiefly grown and the one to which the conditions are best adapted. The yields average about 50 bushels per acre. The low-lying position of the soil and its favorable texture give to it the desirable property of resisting drought. In a country where late droughts are liable to reduce the corn yield this characteristic greatly enhances the value of the soil. The Memphis silt loam is also an excellent grass soil, and wheat does fairly well upon it. Sorghum is raised, but only to a limited extent, for the production of sirup for domestic use, and though it does well on this and other soils, it can not compete with corn and grass.

MIAMI SAND.

The Miami sand is found almost exclusively in the northern and western parts of Posey County. It usually lies in strips from a quarter of a mile to a mile broad along the bluffs facing the Black and Wabash rivers. The foot of the bluff almost invariably forms one boundary, and the type is here bordered by the Yazoo loam, Yazoo sandy loam, or some other river-bottom type. The upland boundary, however, is less distinctly marked. As a rule the soil grades into the Miami silt loam of the upland by slow degrees, and shows no abrupt change of character to mark a definite boundary. In the district just north of Poseyville it extends down and off the bluff into the valley, where it occupies gently undulating topography. But at this point bluff and valley are not as distinct as they are along the Wabash lower

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down, and the change is little more than a gradual descent from high, rolling upland to low, undulating valley.

The character of the soil is somewhat variable. In typical areas it is found to be a medium sand, somewhat loamy, though containing little silt and clay in the soil. This sand is of a dark reddish-brown color, or light gray where it lies more level and has been bleached by the action of the elements. The particles are composed chiefly of rounded quartz grains showing the action of water. There is considerable admixture of heavier material in the subsoil, which becomes somewhat sticky at a depth of from 12 to 14 inches and which at 3 feet is a sticky orange sand, sufficiently mixed with clay to give it a plastic character.

In some localities this soil assumes the character of a sandy loam of finer texture and more coherency than the typical soil. On the other hand, a few areas occur where to a depth of 5 or 6 feet at least the soil is an orange-red sand, and in places where a road cut affords a view of the deep subsoil traces of an irregular stratification are seen.

The soil is well drained. It is so perfectly drained in many cases as to be ill adapted to general farm crops.

It is difficult to say just what has been the origin and method of formation of the Miami sand. It is thought by some to be of loess origin, i. e., to have been transported to its present position at the same time and by similar means as the loess soils of the upland lying to the east and south of it. The roundness of its particles, as well as the lines of stratification in the subsoil, would lead to the conclusion that this material was deposited in water. Others believe it to be wind-blown sand and to be of a later geological age than the loess.

Miami sand is the chief watermelon soil of the county. Its open, leachy texture makes it unreliable for general farm crops, and until melon production was introduced this land was considered very inferior and could be purchased at a low price. But the recognition of its adaptability to melon production has greatly enhanced its value. Watermelons and cantaloupes are raised in large quantities and with good profit. (See Pl. XXVI.) Wheat does very well when it follows melons, but corn, which matures late, is apt to suffer from dry weather. Stock peas often find a place in the system of rotation, and are better adapted to the sandy condition than clover, while they perform a similar office of fertilization. Alfalfa might be profitably introduced on this soil. It is suggested that peaches, which are profitably grown on a similar soil in Michigan, might do well on the Miami sand.

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The following analyses show the texture of the Miami sand:

Mechanical analyses of Miami sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7128	3 miles NW. of Poseyville.	Medium sand, 0 to 8 inches.	1.08	0.00	2.34	23.04	52.60	8.60	8.88	3.68
7126	4 miles W. of Mount Vernon.	Medium sandy loam, 0 to 7 inches.	.60	.00	2.54	20.50	61.54	4.78	6.82	4.12
7127	Subsoil of 7126......	Medium sand, 7 to 36 inches.	.22	.00	2.04	25.70	50.54	3.78	13.78	4.10
7129	Subsoil of 7128......	Medium sand, 8 to 36 inches.	.52	.14	2.74	21.32	54.70	7.36	8.84	4.74

MIAMI SANDY LOAM.

The Miami sandy loam is of limited extent, and consequently of small agricultural importance. It possesses some characteristics, however, which distinguish it as a separate type and give it special adaptability to certain products. The soil varies from a light-brown to black sandy loam, composed of well-rounded, medium sand mixed with heavier material which gives it considerable coherency. Even where the percentage of clay is small the soil possesses a high degree of compactness, which is one of its characteristic features. The soil becomes heavier at a depth of about 10 inches, and, as is the case with most of the Wabash bottom soils, there is considerable fine rounded gravel present in the subsoil. The sandy nature of the soil prevails to a depth of about 3 feet, but below this the deep subsoil differs little from the subsoil of the Yazoo loam, being a rather heavy clay loam mixed with gravel.

The total area of this type is about 0.6 square mile, most of which lies in the Wabash and the Black River bottoms. The principal areas of it occur in tracts of from 400 or 500 to 1,000 acres each. Several of these areas are found on the river flats west of Mount Vernon; others are found north of New Harmony and on Cutoff Island, and still another is found bordering the Black River, just on the northern edge of the county.

Although the land lies almost perfectly level, the soil is generally well drained. In fact, where the sand content exceeds the average the soil is apt to be too well drained for most crops. Its location and physiography, as well as its composition, indicate that the derivation is alluvial. It is hard to say just what cause should be assigned to the peculiar black color which it usually possesses, but this

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is probably due to the admixture of organic material with the heavier portion of the soil, for the sand grains seem to be largely of quartz.

In its crop relations the Miami sandy loam shows a great deal of diversity, and it is hard to assign the reasons for this variation. In some localities where it is devoted to wheat and corn it gives large yields of these crops. Again, the productiveness may fall far below the average for the county. There seems to be little difference in the physical properties of the soil in these two cases, although the more fertile areas contain a slightly larger percentage of clay. In a few cases melons are grown on this soil, and it is thought that larger areas might well be devoted to this industry, especially where the general farm crops do not thrive.

The texture of this soil is shown by the following mechanical analyses:

Mechanical analyses of Miami sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7112	2¼ miles NE. of New Harmony.	Black sandy loam, 0 to 10 inches.	1.54	0.00	1.82	10.80	36.86	12.32	26.74	11.24
7113	Subsoil of 7112.....	Medium sand and clay, 10 to 36 inches.	1.42	.01	1.47	11.78	41.30	12.04	20.58	12.84

MIAMI FINE SANDY LOAM.

Miami fine sandy loam is the name given to one of the river-bottom soils. It is a red-brown or yellowish sandy loam of medium texture, but varies considerably in the percentage of clay it contains. A typical profile shows a mellow sandy loam, 10 inches in depth, overlying red sand of medium texture. Sometimes clay loam is met at a depth varying from 1 to 4 feet. Often the soil is a loose, incoherent sand, resembling beach sand, and in this phase is at times devoid of vegetation.

The soil occurs in low ridges, usually very narrow, immediately bordering upon the Ohio and Wabash rivers. Other patches of it occur throughout the river lowlands, and bordering the lower course of the Black River there is an area of considerable extent. In this locality the soil varies considerably and departs somewhat from the typical section. A single sample is less uniform in texture; there is some coarse sand and fine gravel, and the soil itself possesses a degree of compactness not usually found in this type.

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The areas of this type are as a rule higher than the soils which lie adjacent to them. These sands are the product of alluvial deposition and have been laid down during the inundations which frequently occur. As long as the swollen stream is confined within its narrow channel the flow is so swift that the coarse particles are held in suspension, but as soon as the overflow takes place and the water, spreading out over the broad, level bottoms, is retarded in its rate of flow, the sediment is dropped, the sand being the first to be laid down. Farther from the banks, where the flow is still more sluggish, silt and clay particles are deposited, forming the clay-loam soils.

Nearly all of this soil is under cultivation, although there are some areas of nearly pure sand upon which no crops are grown. Corn is the principal crop, and where there is a considerable proportion of clay in the soil an average yield of from 40 to 45 bushels per acre is secured. Watermelons are also successfully grown on many small patches too sandy for other crops. Fair yields of wheat are secured where the soil lies above high-water mark, and garden vegetables, though not extensively grown, are successful crops on this type of soil.

The texture of typical samples of the soil and subsoil of this soil type is shown in the following table:

Mechanical analyses of Miami fine sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7130	7 miles E. of Mount Vernon.	Medium sandy loam, 0 to 7 inches.	0.93	0.00	0.24	0.34	41.24	35.72	14.82	7.78
7131	Subsoil of 7130	Medium fine, sandy loam, 7 to 36 inches.	1.10	.00	.20	.14	31.34	31.42	25.32	11.22

YAZOO SANDY LOAM.

The Yazoo sandy loam is an important type of soil, covering in all nearly 5 square miles, or 2,752 acres. It is found chiefly in the higher parts of the Wabash River bottoms near New Harmony. As a rule, the type occurs at the foot of the sandy bluffs, from which it is often separated by a narrow talus of Waverly silt loam. Its derivation is somewhat obscure, but it is probably composed of material washed down from the sandy bluffs above and mingled with finer material of the bottoms. It occupies higher ground than the Yazoo loam, which it usually borders on the river-ward side, and as a rule it is separated from this type by a low terrace.

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This soil is a fine sandy loam, resembling the Yazoo loam in surface appearance. The texture varies somewhat. In some cases it is a medium sandy soil with little coherency and with a subsoil of fine yellow sand, but typically the soil to a depth of 12 inches is a fine sandy loam, becoming more cohesive and sticky with silt and clay in the subsoil. At a depth of about 3 feet the clay predominates, giving the soil a desirable moistuıe-holding character.

For corn and wheat, the crops generally grown, this soil is less valuable than the Yazoo loam. The more sandy portions are, however, very well adapted to melon culture and are beginning to be used for this industry. A patch of watermelons was seen which produced about 4 carloads of melons and yielded a money return of about $40 per acre. More of this soil might profitably be devoted to this paying industry.

The texture of this soil type is shown by the following mechanical analyses:

Mechanical analyses of Yazoo sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7116	2 miles E. of New Harmony.	Fine sandy loam, 0 to 8 inches.	1.59	0.14	1.48	2.46	10.76	7.86	71.76	5.52
7118	1 mile E. of New Harmony.	.....do..............	2.34	1.28	10.04	14.76	20.02	5.60	36.84	11.12
7117	Subsoil of 7116....	Sand and clay, 8 to 36 inches.	.73	.14	1.12	1.64	6.34	5.76	72.86	12.10
7119	Subsoil of 7118....	Fine sand and clay, 8 to 36 inches.	.84	.60	7.96	14.02	17.12	4.54	38.38	17.38

YAZOO LOAM.

The Yazoo loam is one of the Wabash River bottom soils. The soil is a brown loam, composed of a mixture of fine sand, silt, and clay, with a good tilth, due to the presence of considerable organic matter. The surface appearance varies considerably, and this variation indicates different phases of the soil. In some localities it is light gray, almost white, when dry. This phase often contains some medium-sized, rounded gravel. The soil here is inferior in fertility to the other phases. In the other extreme the soil presents a dark-brown or black appearance. These black areas occur as small patches within the district over which the type extends, and but for their limited extent might have been recognized as a distinct soil type. This phase occupies minor depressions and owes its peculiar characteristics to the wet conditions which at one time existed in these places. It is generally true that where a soil occupies low land and is continually wet

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it is found to be of a heavier type and to contain more humus than the soil about it, although it may originally have been derived from the same source. Such is the case with this phase of the Yazoo loam.

A typical profile of the soil and subsoil of the Yazoo loam shows a brown loam containing a good deal of fine sand, with an average depth of 8 inches. Lying below this is a loam, somewhat heavier and of a light-brown or orange-yellow color, which contains some coarse sand and waterworn gravel. This, at a depth of about 15 inches, is underlain by a heavier clay loam to a depth of 36 inches or more. Gravel is sometimes present to the amount of 10 or 15 per cent of the entire soil, and in one or two instances stream cuts show a stratum of gravel occurring at a depth of 10 or 15 feet. Those who have engaged in well digging in the neighborhood say that it is quite common to find this layer of gravel in the deep subsoil. This stratum has an important effect on the drainage of the soil, furnishing a natural outlet for the surplus ground waters.

The Yazoo loam is of comparatively limited extent, but of considerable agricultural importance. It covers a total area of 8,320 acres, lying wholly within the Wabash and Lower Black River valleys. It occupies the nearly level flood plain of these streams, to whose agency it owes its origin. The presence of granite and other crystalline pebbles in the soil suggests that the material of which it is formed may be in part reworked glacial drift.

The Yazoo loam is the principal wheat soil of the Wabash bottoms. It is eminently adapted to the growing of wheat, producing grain of excellent quality, with an average yield of 25 bushels per acre and occasional yields of 40 bushels on limited areas where the soil is black and rich. Corn varies a good deal in yield, being more dependent upon the season than wheat, but the average yield is good. Clover and timothy are the hay crops generally raised, and these about complete the list of products at present grown on the Yazoo loam.

The following table of mechanical analyses shows the texture of this soil:

Mechanical analyses of Yazoo loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7114	1½ miles SW. of Griffin.	Sandy loam, 0 to 8 inches.	1.49	1.02	8.04	10.78	10.50	4.86	50.98	13.40
7115	Subsoil of 7114	Clay loam with sand and gravel, 8 to 36 inches.	.75	.74	6.92	8.80	8.58	3.78	44.52	26.66

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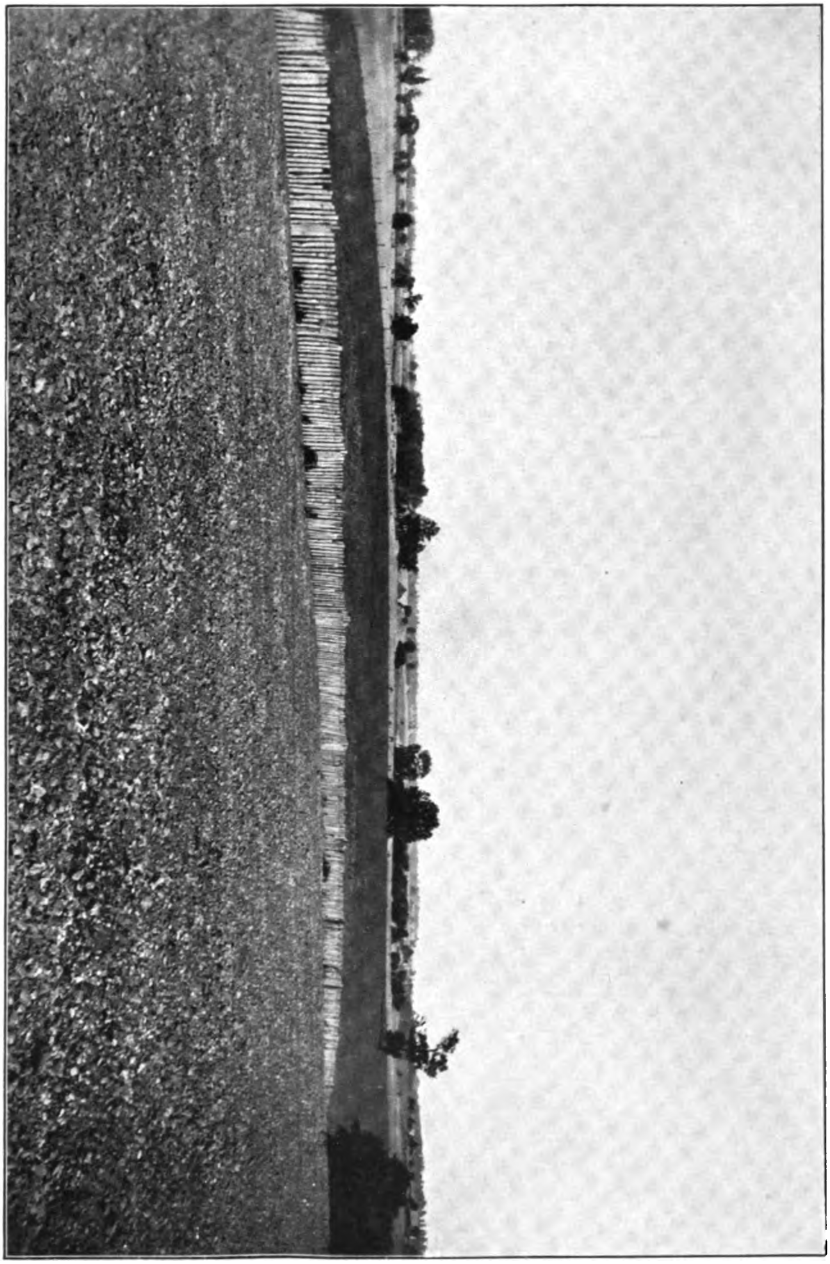

GENERAL VIEW OF THE UPLANDS, POSEY COUNTY AREA, INDIANA.

This is taken on the Miami silt loam, the most important wheat soil in the county.

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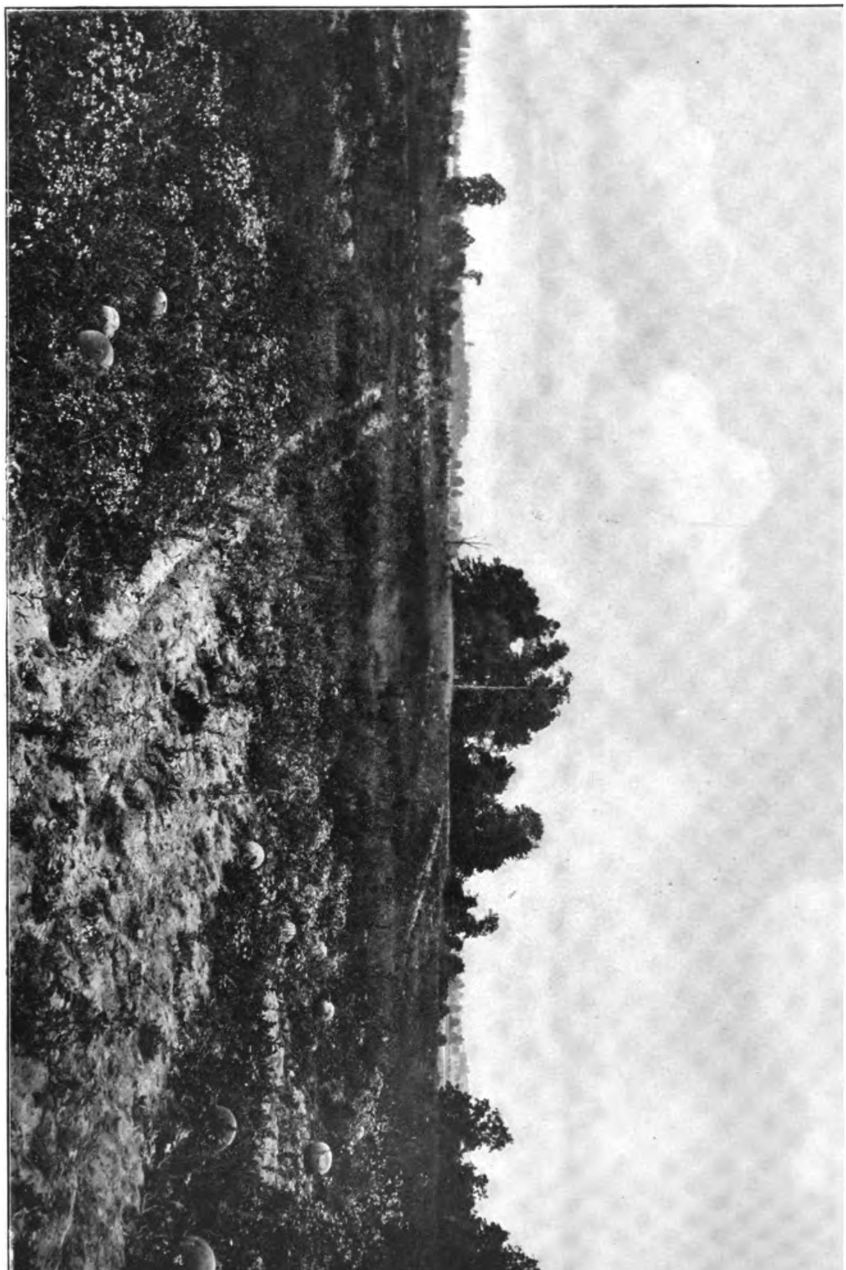

WATERMELON FIELD ON THE MIAMI SAND, POSEY COUNTY AREA, INDIANA.

This sand is an important truck soil in Posey County, famed particularly for its melons.

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YAZOO CLAY.

Next in extent and importance to the Miami silt loam comes the Yazoo clay. The soil to a depth of 7 or 8 inches is a brown clay loam, fairly friable when not too moist and usually containing a small amount of sand, which, together with the intermingled organic material, gives it a desirable tilth. The subsoil differs little from the soil except that it has a more compact structure. This clay is often underlain, at a depth varying all the way from 5 to 20 feet, by sand or sandy clay.

This soil forms the principal alluvial soil of the Wabash and Ohio river valleys. Belts of it are found stretching all along the river boundaries of the county, with occasional breaks where the upland bluffs approach near to the rivers. The belts of Yazoo clay are from a few rods to 3 or 4 miles broad, and where there are other types of soil upon the flats this type occupies the lowest position, forming a flood plain that is in most cases subject to annual overflow. The physiography is that which usually characterizes a river flood plain. The land lies nearly level, with a gentle inclination in the landward direction. There are numerous depressions, bayous, sloughs, and narrow ponds running in a direction generally parallel to the course of the river. Along the bluff that separates the lower bottoms from the upland or from a higher terrace it is usual to find a marshy strip of land or cypress bayou. Occasionally the Yazoo clay is found occupying these higher terraces above the reach of all but the highest floods. Such an area is found along the Wabash River west of the town of Upton. Here the soil departs somewhat from a strict conformity to the typical character. Slight depressions running up and down the valley give the land a gently rolling appearance. In these depressions the soil is black from the presence of humus, while on the low, narrow ridges that separate these depressions is often found a coating of coarse sand 12 inches or more in thickness. These sandy areas are not indicated on the soil map, because they are so limited in extent that they could not be accurately drawn on so small a scale.

As already stated, this soil is a product of alluvial deposition. The forces that have operated in its formation are still active. Much of it is subject to annual overflow, and each flood leaves a coating of sediment or washes away a part of that already deposited, and so the surface soil is constantly renewed and altered. Thus is formed a strong, fertile soil capable of producing good yields of various crops. On account of the danger from overflow, however, it is planted almost exclusively to corn. For the most part the land is owned or rented by farmers having farms in the upland district, who remain on the bottoms only long enough to cultivate and harvest this crop. In those areas where Yazoo clay occupies a higher terrace or "second bottom" winter wheat and other crops are planted, and do remarkably well. Timothy grass and clover average 1½ to 2 tons per acre, and a yield of

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from 25 to 30 bushels of wheat is commonly obtained. Corn on the lower bottoms produces with comparative regularity, a fair average yield being 45 bushels per acre. From its physiographic position and its natural water-holding property the soil is able to resist drought better than the less favored soils. Corn planted late in the sloughs and draws in which the overflow water remains longest will mature and give a generous yield, while late corn on the upland is almost sure to suffer from the summer drought. The pecan is a natural forest growth of this soil, and many of the nuts are annually gathered for the market. Several carefully kept orchards were seen which yield good returns to their owners.

The texture of the soil and subsoil of this type is shown by the following mechanical analyses:

Mechanical analyses of Yazoo clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7106	1 mile E. of Mount Vernon.	Clay loam, 0 to 7 inches.	2.42	0.00	0.00	0.02	0.30	4.50	66.76	28.42
7108	1¼ miles E. of Mount Vernon.	.....do..............	2.60	.00	.02	.02	.06	1.50	70.04	28.46
7107	Subsoil of 7108......	Clay loam, 7 to 36 inches.	2.27	.00	.01	.02	.14	3.06	66.44	30.32
7109	.....do..............	.....do..............	2.27	.00	.01	.02	.04	.98	67.32	30.90

GRIFFIN CLAY.

This is an unimportant soil type that occupies an area of only about 1,600 acres in the valley of the Black River, on the northern edge of the county. Larger areas are supposed to occur in the county adjoining this one to the north. It is entirely different in character from any of the other soils occurring in this area. In its virgin state it is found to be a very compact soil, composed of a mixture of medium to fine gravel, coarse sand, rounded by water action, and clay. The clay is dark brown or mottled in color, very stiff and waxy, and difficult to work. In some areas the gravel is entirely absent, and where this is the case we have a very heavy clay of a tough and waxy character. Taking the whole area into consideration, there is an average gravel content of about 10 per cent, while at times it is as high as 40 per cent.

This soil occupies the broad, level floor of the Black River Valley, forming a part of the river flood plain. Occupying as it does the lowest portions of the river valley and being of a close, impervious

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nature, it would seem to be poorly drained. While this is to a certain extent true, and drainage where employed is beneficial, still most of that which is at present under cultivation is undrained, except for occasional open ditches. The explanation of this may be found in the fact that the soil is generally underlain by a stratum of gravel at a depth of from 5 to 10 feet, which forms a natural drain.

The soil is alluvial in its origin, and the presence of so much gravel may be due to the reworking of glacial material. Pebbles of granite and other foreign rocks point to a glacial origin for the deposits along the river banks.

A large portion of this soil is covered by forest growth, but these are being rapidly cleared and the country is being opened up to cultivation. Corn is the chief product, and considerable wheat and some oats are grown. Large yields are reported. Wheat produced in the season of 1902 in one instance 38 bushels per acre, though this is above the average. Corn will yield from 50 to 60 bushels per acre. It is thus easily seen that though the soil is at first exceedingly difficult to cultivate, still when good cultural methods have been employed for a few years and the soil has become more friable and loamy large returns may be realized.

The following table gives mechanical analyses of typical samples of this soil.

Mechanical analyses of Griffin clay.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7110	3 miles NE. of Griffin.	Compact gravelly clay, 0 to 6 inches.	2.17	1.92	12.34	18.62	12.94	3.76	25.46	24.64
7111	Subsoil of 7110.....	Gravelly clay and coarse sand, 6 to 36 inches.	.90	1.14	14.68	21.20	13.32	3.18	20.24	26.28

GUTHRIE CLAY.

The Guthrie clay is a soil of somewhat variable texture. A typical profile shows a light-gray or whitish silty loam, 5 or 6 inches deep, underlain by a stiff clay subsoil usually mottled with yellow and white. The surface presents a whitish or ashy appearance and when dry is very hard and compact, though the soil itself is not very plastic or tenacious when wet. Silt forms the largest part of the material, and mixed with it are varying amounts of coarse sand and iron concretions

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about the size of buckshot or larger. In areas bordering the Wabash River some coarse sand and fine rounded gravel is present, but not in sufficient quantities to affect, in any marked degree, the agricultural value of the soil.

The Guthrie clay occurs in but one locality. It is found in the southwestern corner of the county, between the Wabash and Ohio rivers, where it occupies an area of 22.8 square miles, most of which lies in Point Township. In this area are found small, isolated patches of Miami sandy loam, Yazoo sandy loam, and Miami silt loam, but the Guthrie clay itself is never met in small detached areas. Its surface appearance is one of the characteristic features of this soil, from which it has derived the local designation of "the woods flats." The land lies almost perfectly level and is for the most part covered with forest. A few low ridges occur, but these are usually occupied by some other type of soil. From the topography it is evident that the soil occupies an old Ohio-Wabash flood plain that the deeper cutting of the stream valley has left above ordinary high water. From the present river-flood plains, which are occupied by the Yazoo clay, this older terrace is separated by a low bluff from 10 to 20 feet in height. At times of very high water, which may occur once in ten or fifteen years, the river floods rise above this bluff and cover the broad area of the Guthrie clay, leaving only the ridges above water. Such inundations have left their marks in scattered patches of sand and water-washed gravel. It was at first thought that the origin of the soil was by deposition from these flood waters, but on closer study it was found that although the soil has been considerably added to and altered in character by these inundations, yet it is not strictly an alluvial soil. It is supposed that the soil was derived, like the Miami silt loam, from the loess and that its present character is due to physical and chemical changes that have taken place since its accumulation ages ago. The changes are those which commonly result from low-lying, level topography, prevailingly poor drainage, and consequent wet conditions.

The soil is one of the least valuable of all the Posey County types, and this fact seems to be chiefly due to its poor drainage. Only in very dry seasons does it produce a fair yield of corn. Wheat produces well only in favorable seasons. Some underdrainage has been done, with good results, but the present need is for large outlet ditches into which smaller ditches and tile lines might be led. The larger portion of this soil is now wooded, but with a good system of ditches and tile drainage there is reason to suppose that much of the area may be converted into productive land, adapted to grain and grass. Application of lime, it is thought, would improve the tilth and increase the productiveness of this soil.

At present grass and small grain are the crops to which the soil is best adapted. Wheat averages about 15 bushels per acre and timothy

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hay from a ton to a ton and a half. Clover is said to do well and to produce an especially good crop of seed. These yields, of course, refer to those parts of the area that have been under cultivation for some time and have lost to some degree the unfavorable character of the soil in its original state.

Mechanical analyses of this soil are given in the following table:

Mechanical analyses of Guthrie clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7136	Point Township....	Clay, 0 to 7 inches.	1.73	0.90	2.78	1.48	6.46	7.78	54.20	25.86
7138	7 miles SW. of Mount Vernon.	.....do..............	2.13	1.76	3.50	1.96	2.42	2.58	51.74	36.16
7137	Subsoil of 7136......	Clay, 7 to 36 inches.	.89	1.24	2.22	.96	5.12	5.82	55.50	29.18
7139	Subsoil of 7138......	.....do..............	.92	2.80	3.44	1.72	2.02	2.40	48.46	38.48

AGRICULTURAL CONDITIONS.

Posey County is a prosperous agricultural community. On the whole, the farming classes are a progressive people. This is evident from the appearance of homes, farms, and farm equipments throughout the county. There is a general recognition of the fact that well-constructed barns and sheds for the protection of farming implements pay in the end, and farmers make an effort to have as substantial a shelter for their stock as possible. The typical dwelling is a two-story frame building. Many of the dwellings have modern conveniences and comforts, and in a large number of cases windmills furnish an adequate water supply for house and stable purposes.

The county is divided according to the rectangular system, and the roads conform in general to section lines. The farms vary in size from only a few acres to as many as 3,000, the average being about 65 acres. As the price of land varies according to location and character of the soil, a correct estimate could hardly be made of the value of land in the county, but much of it can not be bought for less than $100 per acre. In general the farms are managed by the owners. Proprietors of larger tracts sometimes subdivide their lands and rent small holdings to tenants, who pay rent in a share of the produce or less frequently in money.

White labor is employed exclusively, and this is of an efficient character. In many cases where the farms are small no regular hired hands are employed except at times of special pressure, such as wheat

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harvesting, etc. At other times the farmer is able with the help of his boys to carry on the regular work of the farm.

The staple crops of the county are corn, wheat, hay, and melons. The upland, which is best adapted to the cultivation of wheat, yields an average of 20 bushels per acre, and of corn about 35 bushels, while from 1½ to 3 tons of clover and timothy hay are cut to the acre. By far the greater amount of corn is grown on the soils of the Ohio and Wabash bottoms, and in some cases they average as much as 65 bushels to the acre. Soils admirably adapted to the production of wheat and grass are to be found among these river-bottom types. The sandy hills and ridges which extend in a semicircle about the county are made use of for melon growing. The melon industry is one for which the county is famous. The quality of the watermelons grown on the sandy soils is very superior, and they find a ready market in Cleveland, Indianapolis, Chicago, and even as far east as Pittsburg and Buffalo. Later in the season shipments are made to New Orleans. Poseyville is the principal shipping point, and 300 or 400 carloads are shipped annually from this place to all points in the Middle West. Cantaloupes also thrive on the sandy soils, and their cultivation is a very profitable industry, although they are not so easily handled as the watermelons. Melon growing has been carried on in this region for many years. The first shipments were made about forty years ago. But though not a new one, the industry is still growing and is capable of much more extensive development. The Miami sand and many areas of the Miami sandy loam and Yazoo sandy loam are well adapted to the production of an excellent grade of melons. Outside the melon industry fruit culture is carried on only to a limited extent. Enough is grown, however, to make it evident that many varieties would do well. Practically none is shipped outside the county, the greater proportion being utilized for home purposes. Apples, peaches, pears, plums, and grapes all do very well, and few farms are without an orchard or grape arbor.

There is a general recognition of adaptation of soil to crops, evidences of which can be observed in any part of the county—as, for instance, the silt soil of the upland for wheat, melons on the sand hills and ridges, corn along the upland stream bottoms and river flats, etc.

As far as soil and climatic conditions are concerned Posey County is eminently adapted to the production of tobacco of the heavy export type. A soil survey was made in Union County, Ky., just previous to this survey, and all the tobacco soils found there occur also in Posey County. There is an erroneous idea among farmers of Posey County that their soil is not as well adapted to tobacco culture as are the soils in Henderson and Union counties, immediately across the river; but the Miami silt loam and the Waverly silt loam, the two chief tobacco soils of this part of Kentucky, are found in Posey County, with the same properties and subject to the same climatic influences. The

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growing of this crop, however, requires considerable skill and experience, and a lack of this is probably the cause of failure on the part of the Indiana farmers to produce a crop of tobacco equal to the Kentucky crops. And so the advisability of introducing tobacco into this locality is a debatable question, and yet it is well for the farmer to know that this is one of the many crops to which his soil is adapted.

No commercial fertilizers are used, barnyard manure and decayed wheat straw furnishing a good supply of soil-enriching material. More care might well be taken, however, to preserve and utilize this store of fertilizer. Experience demonstrates that the work and expense of conserving and applying barnyard manure to the soil is sure to pay in the end.

Posey County has a favorable location with respect to markets for her produce. Three railroads—the Illinois Central, Louisville and Nashville, and Evansville and Terre Haute—traverse the area, affording transportation facilities to Chicago, St. Louis, Indianapolis, Louisville, Cincinnati, and Nashville, while the waterway afforded by the Ohio River makes traffic by steamboat practicable for the river towns. The county is furnished with a good system of wagon roads, making internal communication convenient. These roads are now being greatly improved by the construction of macadam roadbeds of broken limestone.

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SOIL SURVEY OF TAZEWELL COUNTY, ILLINOIS.

By JAY A. BONSTEEL and PARTY, IN COOPERATION WITH THE ILLINOIS EXPERIMENT STATION.

LOCATION AND BOUNDARIES OF THE AREA.

Tazewell County, Ill., comprises an area of about 645 square miles, located on the eastern bank of the Illinois River, slightly northwest of the center of the State. It lies between the parallels 40° 20′ and 40° 50′ north latitude, and the meridian 89° 30′ west from Greenwich nearly bisects it. The county lies about equally distant from St. Louis and Chicago, slightly to the west of the line joining the two places. Pekin, a city of over 8,000 inhabitants, is the county seat. It is located on the Illinois River. Besides steamboat connection with St. Louis, several trunk lines afford railroad communication with all parts of the country. Washington, a town of about 1,500 inhabitants, is located in the eastern part of the county, while Delavan, having a population nearly as large, is located in the southern part. Mackinaw, Minier, Morton, and Tremont are smaller towns located in the eastern part of the county. Tazewell County has a total population of about 33,000. Its chief industry is agriculture. (See fig. 13.)

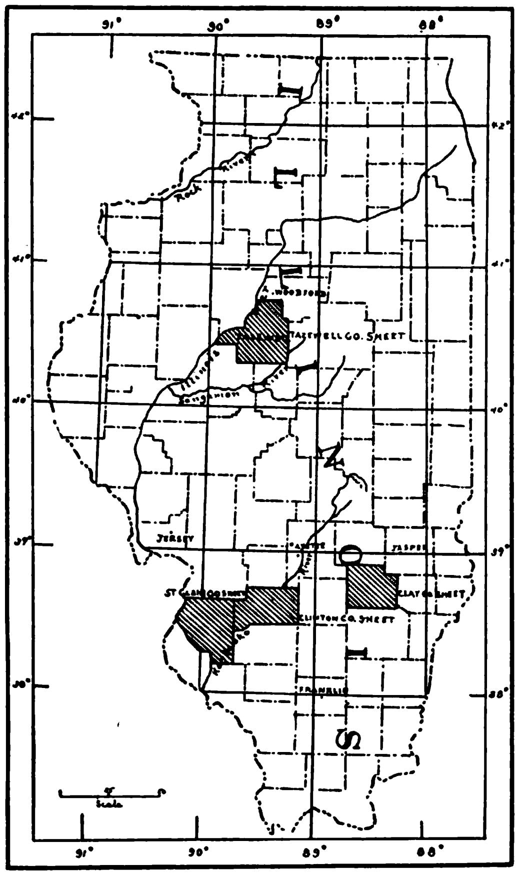

FIG. 13.—Sketch map showing areas surveyed in Illinois

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Tazewell County forms a portion of the Middle West first explored by the French soldiers and priests. La Salle in 1671 passed down the Illinois River to a point near its mouth, making a map of its course and its tributaries. He was followed in 1673 by Marquette, Joliet, and their party, who made use of the Illinois River on their return from the discovery of the headwaters of the Mississippi River. In 1680 La Salle, with Henri Tonti as his lieutenant, began a long series of explorations which accomplished the mapping of the Mississippi River and its tributaries and laid the foundation for French dominion and occupation west of the Allegheny Mountains. Fort Creve Cœur was erected by Tonti near the present site of Wesley, and while only occupied temporarily it formed the first foothold of civilization in this region. At that time the Illinois Indians occupied the banks of the river which still bears their name. They subsisted by hunting, fishing, and the cultivation of small plats of maize. Although the French held this region until 1763, little progress was made in colonization. Only scattered trading posts acknowledged the dominion of France. In 1778 Col. Rogers Clark took possession of the region for the new colonial government, and the Northwest Territory became a part of the State of Virginia. In August, 1778, a combined force of French and Indians was assembled at Wesley. They proceeded to the southern end of Lake Michigan and captured a fortified British post.

The first permanent white settlers of Tazewell County were Nathan Dillon and his brothers, who in 1823 located near the southern end of Tremont Prairie. In 1824 the first log house was built by Jonathan Tharp on the site of Pekin. Soon after, the Tremont and Delavan colonists arrived, bringing improved farm implements. In 1825 the first gristmill, operated by horse or ox power, was erected in Elm Grove Township. Steam navigation began in 1828, all water transportation up to that time having been done by keel boats.

The early settlers were chiefly engaged in agriculture, producing corn, wheat, and oats, and raising cattle. Banks were soon established, schools and churches were organized, and the new country developed rapidly. In 1845 distilleries and breweries furnished a local market for surplus grain. At present the population of the county is chiefly engaged in agriculture. Farm machinery is manufactured in the county, while distilleries, breweries, and a glucose factory afford a local market for grain.

CLIMATE.

The following table, compiled from Weather Bureau records, gives the normal monthly and annual temperature and precipitation at Peoria and Mount Pulaski, no station being located in Tazewell County. Peoria is situated in Peoria County, across the Illinois River and just

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north of the area surveyed, and Mount Pulaski lies about 20 miles south of the area.

Mean monthly and annual temperature and precipitation.

Month.	Temperature.		Precipitation.	
	Peoria.	Mount Pulaski.	Peoria.	Mount Pulaski.
	° F.	° F.	*Inches.*	*Inches.*
January	28.5	27.8	2.12	2.26
February	25.4	27.8	1.96	2.27
March	37.7	38.0	3.42	3.05
April	52.6	52.9	1.89	1.98
May	63.1	62.4	4.48	3.69
June	73.6	72.1	3.12	4.04
July	78.0	76.1	2.50	3.49
August	75.3	73.9	2.81	2.54
September	67.1	67.2	4.08	2.91
October	56.9	54.6	2.22	1.82
November	40.3	40.2	1.87	2.56
December	29.1	32.0	1.61	2.01
Year	52.3	52.1	32.06	32.62

The foregoing table gives no idea of the annual extremes of temperature, which are usually within the limits of a maximum of 100° and a minimum of −20° F. Danger from killing frost is generally past by the third week of May, and need not be anticipated in the fall before the latter part of September. This gives a growing season for even the tenderest crops of sixteen weeks' duration. This is long enough to allow the growing of successive crops of many kinds of truck, an industry but little developed at the present time in the area surveyed, but the introduction of which on several important types of soil is recommended elsewhere in this report.

PHYSIOGRAPHY AND GEOLOGY.

The high bluff which forms the eastern boundary of the Illinois River Valley divides Tazewell County into two main physiographic regions. From the northern border of the county southward to the vicinity of Pekin the bluff attains an average elevation of about 200 feet, and a narrow second bottom having an average breadth of about 2 miles intervenes between it and the river. Below Pekin the bluff swings southwestward to the Mackinaw River and becomes gradually lower until it is scarcely noticeable as it descends into the plain southeast of Delavan.

The region to the east of this bluff line consists of a high, rolling plateau, interspersed with broad, level prairies, and deeply trenched through the middle by the Mackinaw River. In the southern part of the county several smaller streams, tributary to the Illinois, have cut

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deep, V-shaped gorges that extend back from the bluff line an average distance of 2 or 3 miles and reach out into the uplands through shallow, wooded streams.

The southwestern portion of Tazewell County constitutes an ancient joint flood plain of the Illinois and Mackinaw rivers. It was formed principally as a delta and river terrace deposit during the closing stages of the Glacial epoch. Since the time of its formation the volume of both rivers has been considerably diminished and their level has also changed. In consequence they have both cut minor channels across their old flood plain, leaving it as a second bottom or terrace region. This alluvial plain has been modified further through the drifting of extensive sand dunes across its surface. Several small swamps originally found within this region have been drained naturally or artificially within recent times.

Geologically considered, Tazewell County consists of a basal structure of sandstones and shales belonging to the Upper Carboniferous rocks. The outcrops of these strata are few and scattered, occurring principally in the upper gorges cut through the bluff line by the smaller tributaries of the Illinois River. A 4-foot seam of coal, outcropping near the foot of the bluff, is of considerable economic importance in the development of the region. It is mined on a small scale at several points in the county for the use of railroads and manufacturing establishments. The surface features of the county are entirely formed by the deposits of Pleistocene and recent geologic age.

Tazewell County was invaded by the ice sheets of both the Illinois and Wisconsin glaciation. The former ice sheet extended entirely over the county, while the Wisconsin ice sheet only reached to a limit approximately marked by the principal Illinois River bluff line. That portion of the county lying to the west of this line was occupied during this stage by one of the chief drainage lines of this latest ice invasion. The series of deposits in this territory is therefore alluvial rather than glacial in origin. During the Wisconsin glaciation the older deposits of the Illinois stage were almost entirely overridden and covered up in Tazewell County, either by the Wisconsin till or by the fluvio-glacial deposits formed in the alluvial tracts by marginal drainage from the Wisconsin glacier.

The general section in the glaciated upland is uniform in character, though the thickness of the deposits varies considerably in different parts of the county. The Wisconsin till attains a thickness of from 30 to 60 feet. Below the surface of the soil it consists of a yellowish-gray or dark-drab silty clay of massive structure and uniform texture. A few large bowlders of granite, porphyry, diabase, conglomerate, sandstone, and limestone are scattered over the surface, particularly in the moraine belts; otherwise this till is free from stone, gravel, or coarse sand. It is underlain by about 10 feet of medium loamy sand,

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showing local stratification and cross bedding. This rests upon a thin bowlder bed, containing the greater part of the large erratics found in the region. The bowlder bed rests upon a gravelly blue till or bowlder clay of considerable thickness. Near the margin of the bluff the gravelly clay is underlain by a massive bed of gravel and sand that has been cemented into a coarse conglomerate through the deposition of calcium carbonate cement. The carboniferous rocks form the basis upon which this rests. The upland soils are derived entirely from the glacial deposits of the Wisconsin stage.

The general section through the alluvial region is entirely different. Near the bluff line south of Pekin and immediately west of Delavan the surface soil is underlain by a deposit of yellow silt and clay known geologically as the valley loess. At a depth of about 6 feet this grades downward into a fine yellow sand which shows unmistakable evidence of stratification. The sand is only 5 or 6 feet in depth near the eastern border of the alluvial region, but thickens rapidly toward the west on account of the slope of the surface on which it rests. Where its lower limits could be seen it was underlain by a thin seam of gravel, which in turn rested upon the pebbly blue clay of the older glaciation.

The present bottom lands of the Illinois and Mackinaw rivers are formed by recent alluvial deposits of loam and sand mixed with a considerable amount of organic matter, which predominates in some localities to such an extent that typical beds of peat are formed along the margins of the bottoms.

The formation of the sand dunes already mentioned is still in progress, as is also the natural draining of the swamps, the silting up of the bottom lands, and the erosion performed by the minor streams along the bluff line. This constitutes the closing chapter of the geological history of the county.

The alluvial portion of the area is marked by a considerable diversity of soil types in contrast with the uniformity of the upland soils. Eight of the ten soil types of the county are found wholly or in part within the alluvial region, while the entire upland country contains but two principal types, with a third slightly developed along the larger stream courses.

SOILS.

Ten soil types are found within the limits of Tazewell County. These represent variations in the texture, structure, surface configuration, and the drainage of the materials which constitute the surface 4 feet of the area.

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The areas occupied by the different soil types in Tazewell County are given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Tazewell silt loam	224,960	54.5	Yazoo clay	13,696	3.3
Miami black clay loam	61,184	14.8	Peat	1,664	.5
Miami loam	32,512	7.8	Mackinaw gravel	1,088	.3
Lintonia loam	29,056	7.0	Yazoo sandy loam	128	
Delavan silt loam	25,600	6.2	Total	412,864	
Miami fine sand	22,976	5.6			

MIAMI FINE SAND.

The Miami fine sand constitutes irregular ridges and hills of medium and fine-grained sand inclosing bowl-shaped or irregular hollows, whose soils consist of a slightly more loamy sand. There is no distinct division between the soil and subsoil of this type. The typical soil, from the surface to a depth of 40 inches, is that of a brown or yellowish sand of fine to coarse grain, made somewhat loamy through the presence of a small amount of fine particles, chiefly silt and clay, together with varying proportions of partially decomposed organic matter. The highest summits of the sand hills and irregular driftlike areas on the sides of the hills frequently consist of incoherent orange or yellow sand. On the windward side of some of the hills small cavernous gashes are found. From these gashes the most recent wind storms have carried away the drifting sand, depositing it in more sheltered positions. No large area is denuded by any one storm, and the points of attack vary from time to time, though the prevailing westerly and northwesterly winds cause a gradual progressive migration of the sand toward the east. The area of deposition usually forms a much larger exposed surface than the area of derivation, for the sand is spread out to a depth of 5 or 6 inches or a foot to the lee of a small pitlike opening, the minor variations in wind direction giving rise to a fan-shaped distribution from a central point.

The greater portion of the Miami fine sand lies in Spring Lake Township, between the Illinois and Mackinaw bottoms. Smaller areas are found in the northwestern part of Cincinnati Township and in Malone Township. The large continuous masses of the higher sand ridges appear along the horizon like miniature mountain ranges, while the low undulations of the smaller sand ridges extend to the eastward of the main mass, forming low outliers that foreshadow the slow advance of the sand hills across the level plains bordering them on the east. The broad valley of the Mackinaw curving southeastward from the mouth of the river through Sand Prairie Township presents an effectual barrier to the slow westward movement of the main mass lying in Spring Lake Township.

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A notable peculiarity of the Miami fine sand area is the absence of minor stream drainage. Rain falling upon the sand ridges sinks through the porous mass, and for the most part issues along the cliff lines as subsurface drainage into the Mackinaw and Illinois rivers. A portion of the water derived from torrential downpours accumulates temporarily in the hollows between the surrounding sand hills, but ultimately it finds its outlet by seepage downward, no permanent channels being formed. Aside from the slow accumulation of the sand and silt in the small hollows among the sand hills, erosion, transportation, and deposition are carried on by æolian and not aqueous forces.

The sand which forms these hills, impelled by the wind, has migrated from the low cliffs along the Illinois River and has halted between wind storms at various times in its progress. The advance of the sand across the ancient Mackinaw flood plain has occupied all the immeasurable time since the Mackinaw and Illinois rivers established their present channels. During the thousands of years that have elapsed hills of more than 100 feet in elevation and of several square miles in extent have been piled up and pushed forward across the plain. Where the supply of the sand has been greatest and the sweep of the wind least obstructed the progress has been most continuous and most rapid. The growth of trees and grasses has delayed the migration by diminishing the force of impact of the wind and by holding the soil together with an intricate network of roots and a spongy mat of half-decayed vegetation on and within the soil, ultimately giving rise to the slightly loamy character and brownish color of the less exposed portions of the area.

The Miami fine sand consists of partly rounded grains of quartz stained to a rusty yellow or orange by iron.

The natural growth on this soil consists of scattered and stunted black-jack oak and coarse bunch grass.

Some special adaptation of crops to soil has been undertaken on this type. Small vineyards occupy scattered positions, usually where the slopes are gentle and the soil somewhat loamy through the addition of organic matter by natural causes. Sweet potatoes and watermelons are raised to a limited extent, and a part of the area has been devoted to small orchards of peaches and pears. The main crops produced, however, are those common to the area. Except in seasons of drought, corn and clover produce fair yields. Rye is raised to a greater extent than wheat, and both crops are subordinate to corn.

The Miami fine sand affords an opportunity for the production of special truck crops. Elsewhere on this soil type peaches, cherries, and plums are raised successfully, while small fruits also thrive. Of the truck crops, watermelons, cantaloupes, early tomatoes, eggplants, peppers, early pease, early green corn, and other truck crops could be produced to a greater advantage than any of the grain crops now grown.

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In order to furnish nitrogen and organic matter to this sandy soil cowpeas or other leguminous crops should be used both for plowing under and to furnish forage for stock, thus insuring an additional local supply of stable manure.

The following mechanical analysis shows the large proportion of sand in this soil and exhibits the presence of some, though little, organic matter:

Mechanical analysis of Miami fine sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6658	7¾ miles W. of Delavan.	Brown loamy sand, 0 to 40 inches.	0.53	0.10	3.92	22.26	62.20	6.24	2.86	2.42

MIAMI LOAM.

The Miami loam consists of a brown, slightly sandy loam soil about 10 inches in depth. The surface soil is friable, easily worked, free from stones, and generally quite level. It contains about 10 per cent of medium sand. The subsoil has a depth varying between 20 and 40 inches. It consists of a brownish-yellow loam. This immediate subsoil is usually underlain by a reddish gravelly loam. Near the cliff line the gravelly loam is reached at a depth of 30 or 40 inches, while in the central portion of the larger areas the thickness of the soil and subsoil above the gravel band amounts to 8 or 10 feet.

The Miami loam occurs in small areas between the sand hills in Spring Lake and Sand Prairie townships, and is more extensively developed in Cincinnati Township.

The surface of this soil type is almost entirely level or gently undulating. Small strips and hillocks of Miami fine sand are found over the plains of Miami loam, constituting the greatest change of slope found within the type. Slight depressions in the formation are more loamy than the general average of the type because of the accumulation of silt and clay carried in by the heavier rains, and also through the incorporation of partly decayed organic matter, vegetation being of a slightly ranker growth in these depressions.

The Miami loam borders the Mackinaw bottoms on both sides of the river, and the natural drainage of the type is accomplished through the channels of many small streams along the margin of the type. A large part of the precipitation on this formation is drained off by percolation through the underlying gravel and sand.

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The Miami loam constitutes the original surface of a delta deposit formed by the Mackinaw River during the closing stages of the Glacial epoch, while the Illinois River occupied a much larger expanse of bottom than it does at present. The materials first deposited consisted of sand, gravel, and silt, brought in by the Mackinaw from its upper courses and piled together in the form of cross-bedded and stratified deposits of sand and gravel. Later the finer surface loam was spread out, forming a level plain. When the surface of the Illinois River had been lowered sufficiently to expose this plain, the Mackinaw was enabled gradually to carve its present bottom lands from the deposits which it had formerly made. The Illinois River also washed the frontal slopes, flowing through the channels which now exist as lakes and sloughs. Here the prominent influence of water ceased and the wind, undercutting the sandy bluffs, began the formation of the dunes and hillocks of sand. As the advance guard of sand hillocks moved across the plain a small portion of the coarser sand lodged behind and became incorporated with the surface soil. The more violent windstorms also distributed occasional small amounts of sand across the plain, and the Miami loam assumed its present slightly sandy character at the surface, though retaining the heavier original loam in the subsoil.

The mineral matter constituting this soil consists of a complex mixture of fine particles collected by the Mackinaw from the glaciated uplands and sorted by the varying velocities of the transporting currents. The finer particles selected and redeposited over the ancient flood plain and delta of the river form the chief portion of the present Miami loam. Since the original source of this material consisted of a heterogeneous mass of disintegrated mineral matter, the resulting soil is more complex than the average of sedimentary deposits. In addition to the siliceous and aluminous body mass of the soil there are present smaller amounts of partly weathered silicates of potash, lime, magnesia, and iron, derived from the igneous rocks transported to the upland from distant localities by glacial ice and hence removed by the Mackinaw drainage to form a portion of the Miami loam. The most striking mineralogical peculiarity of this formation, however, is the presence in the subsoil, and through the gravel underlying it, of large amounts of carbonate of lime. The original source of this lime is the magnesian limestones of northeastern Illinois. The older till of the Illinois glaciation is filled with bowlders, gravel, and fragments of much smaller size formed from the limestone. This material, reworked by the Mackinaw and built into its flood plain, lies at present above the permanent water table and is subject to continual solution and almost immediate redeposition in the form of calcium carbonate cement, formed most extensively in the larger gravel bands of the Mackinaw delta. A considerable amount of this carbonate of lime is being dis-

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solved each year and brought into the soil and subsoil of the Miami loam by the capillary circulation of the soil solutions. It forms an essential part of the easily soluble matter present in most of the soil types of the area, and its presence is important, not only as a plant food, but on account of the rôle it plays in maintaining a proper physical condition in the soil and subsoil.

Under the present system of agriculture the Miami loam is farmed in a regular rotation of corn, wheat, oats, and grass. Corn produces from 35 to 50 bushels per acre; wheat, 18 to 25 bushels per acre; oats, 25 to 35 bushels per acre; and grass, about 1 ton of hay per acre.

The Miami loam is best adapted to the production of sugar corn, green peas, and tomatoes for canning purposes. Different varieties of pears—notably the Kieffer—could be grown to advantage. The canning industry would bring larger and more certain returns to the farmers located upon this type than the present system of grain farming, while the fertility of the land could be easily maintained and properly increased through feeding the by-products of the canning factory to the farm stock.

The textural peculiarities of this soil, as shown by the following mechanical analyses, its admirable natural underdrainage, its level surface, and its climatic surroundings, with the adaptation of crops indicated, should cause it to be esteemed of higher value than it has been.

Mechanical analyses of Miami loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6650	3 miles SW. of Pekin.	Brown sandy loam, 0 to 14 inches.	1.69	3.68	15.40	8.52	11.70	7.74	35.26	18.14
6652	6 miles SW. of Pekin.	Brown sandy loam, 0 to 12 inches.	2.80	1.78	17.20	11.96	5.02	4.04	35.74	24.08
6651	Subsoil of 6650....	Yellow loam, 14 to 30 inches.	1.16	3.74	18.84	9.04	13.14	5.92	29.36	19.82
6653	Subsoil of 6652....	Brown loam, 12 to 28 inches.	1.78	2.22	17.24	14.24	5.88	1.90	33.10	25.36

LINTONIA LOAM.

The Lintonia loam consists of a slightly sandy, though sticky, brown or black loam, having a depth of about 10 inches. It is underlain by a reddish-brown, yellow, or gray silty loam subsoil. The soil contains a considerable proportion of organic matter, and this, together with the fine sand, causes it to become granular and friable when partly dried. Locally small amounts of fine gravel are scattered over the surface,

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and in the same manner limited areas contain small concretionary pebbles of hydrated iron oxide (limonite) in the subsoil.

The Lintonia loam is extensively developed in the bottom lands along the Mackinaw River, while small areas occur along the Illinois, near the bluff line south of Pekin, and along the narrow bottoms of streams tributary to the Illinois and Mackinaw rivers. The surface of this soil type lies at an elevation of 10 or 15 feet above the normal water level of the streams which it borders. It is mainly level or only slightly irregular where indented by sloughs or old stream channels, cut during former overflows of the rivers. At the present time it is rarely flooded except by the largest freshets. It is well drained during the crop season by numerous small streams, while its proximity to the river, its low-lying position, and its retentive texture maintain an abundant moisture supply for the production of large crops of corn, wheat, oats, and grass. In addition to the natural drainage, large areas are tile drained. The water table stands at a depth of 4 or 5 feet below the surface.

This soil consists of the recent alluvial deposits of the Mackinaw and Illinois rivers, formed by small annual accumulations of fine sand, silt, and clay, mixed with a large proportion of organic matter. Some areas have been formed by the washing in of silt sediments from the surrounding soils. The marginal parts of this type along the streams are still subject to occasional overflow and to the local accumulation of new material. A small portion of this soil type is included in the artificial drainage area of Spring Lake and Sand Prairie townships.

Near the Mason County line there are many low spots having either a rusty, reddish-brown color or a grayish to ash-colored surface. The red spots are underlain by a yellow, ocherous, clayey subsoil, containing a considerable quantity of iron concretions or "iron gravel." The cultivated fields containing these red spots show a flourishing crop of rye and wheat over the general soil type, while the grain over the red areas is entirely killed out, yellowed, or stunted.

The ash-colored spots show a surface efflorescence, accumulating in some cases sufficiently to form a thin, brittle crust. The wheat and rye over these gray spots continue to grow, though not in as healthy a condition as on the general average of the soil.

Corn yields from 40 to 50 bushels per acre on the average; wheat, 25 bushels; oats, about 40 bushels, and hay from 1 to 1½ tons per acre. On some fields located on this type corn is raised four or five years in succession before the rotation is changed, producing excellent crops each year.

In addition to the grain crops produced on the Lintonia loam, cabbage, onions, cucumbers, and other market-garden crops could be grown to good advantage.

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The mechanical analyses of this soil are given below:

Mechanical analyses of Lintonia loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6640	8 miles SW. of Pekin.	Brown loam, 0 to 15 inches.	2.88	0.44	0.70	1.20	2.40	7.60	72.12	15.20
6636	2¾ miles NW. of Green Valley.	Brown loam, 0 to 18 inches.	3.93	.20	1.16	3.14	18.60	14.76	43.42	18.72
6638	2¾ miles SW. of Pekin.	Brown loam, 0 to 10 inches.	3.36	.12	.46	1.10	6.02	6.84	63.62	21.84
6639	Subsoil of 6638	Brown loam, 10 to 30 inches.	2.65	.10	.56	2.60	12.90	11.20	54.88	17.00
6641	Subsoil of 6640	Brown loam, 15 to 40 inches.	1.85	.70	2.64	2.80	6.90	8.72	58.52	19.66
6637	Subsoil of 6636	Yellow silty clay, 18 to 40 inches.	.57	.40	1.72	3.06	6.90	7.46	57.64	22.56

PEAT.

Along the margin of the Mackinaw bottoms at the foot of the cliffs there are several small areas of peat. The soil consists of a black mass of partly decayed vegetable matter mixed with silt or clay. It forms a spongy, incoherent mass, extending to varying depths. Near the margins the proportion of organic matter is diminished and the depth of the deposit decreases to 3 or 4 feet. Near the center of the areas the peat has accumulated in its greatest purity to a depth of 10 or 15 feet. It is underlain by medium-sized white gravel and grayish sand. The surface of the peat is almost level and its drainage has been accomplished by artificial ditches, which are cut almost or entirely through the mass to the underlying gravel.

This peat has been formed through the agency of large springs that form the outlet of the subsurface drainage of the adjoining alluvial plain. The springs reach the surface both along the cliff line and through the gravel bed which underlies the peat. The sediments deposited by the Mackinaw River have been built up during recent times along the present stream channels, leaving low hollows near the cliffs in which the spring water has accumulated. These pools have gradually grown up to water grasses and moss, and this vegetation decaying has accumulated to form the peat beds. The rain wash from the cliff slopes and the encroachment of the Mackinaw sediments in times of overflow have furnished the mineral matter which enters into the composition of the mass.

Until the drainage ditches which have reclaimed this area were cut,

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the water table reached the surface of the soil. The ditches have lowered the level of permanent saturation to a depth of 4 or 5 feet, and the peat is now cultivated to corn, wheat, oats, and grass. The average yield of corn is from 35 to 40 bushels per acre; that of wheat, about 20 bushels; oats, 30 to 35 bushels, and grass about 1 ton per acre. Some celery has been cultivated on this soil. The peat is too tender to support the weight of a large corn crop against strong winds, and the surface is apt to catch fire when the refuse and stubble of a former crop are burned off.

The peat areas in Tazewell County present an excellent opportunity for the production of celery and onions—two crops which have been raised upon peat soils with marked success in other areas. The labor attending the cultivation of these crops is much greater than that involved in grain production, but the crop value per acre is also much greater.

DELAVAN SILT LOAM.

The Delavan silt loam consists of a silty and fine sandy loam that maintains its characteristic texture and color to a depth varying from 18 to 30 inches. Down to the plow sole, a depth of about 6 inches, this soil is massive and homogeneous. Below this depth to the limit of the surface soil the mass is somewhat more friable and loamy. The surface soil is underlain by a deep-reddish or yellowish-brown silty subsoil of a heavier texture than the surface soil. It grades imperceptibly into the characteristic yellow silt loam, known geologically as valley loess. Natural stream cuts, wells, and railway excavations show that this loess grades downward into a fine, stratified yellow sand and that the entire mass rests upon the pebbly till of the Illinois glaciation. The complete section differs materially from that of the Tazewell silt loam given elsewhere, and with the physiographic differences forms the most constant and easily recognized basis for discrimination between the two types.

The Delavan silt loam comprises the higher lying portion of a level plain immediately to the west of the glaciated upland of the county. With the exception of narrow strips along the Mackinaw River and along the Illinois bluffs near Pekin and Circleville, the Delavan silt loam occupies a solid block of territory in Delavan, Malone, and Sand Prairie townships.

The surface of this soil type is uniformly level, forming a broad expanse of low prairie. No deep stream valleys have been cut into this type except where the Mackinaw has divided off the northern portions of the area. The minor streams occupy low swales, chiefly distinguishable from the average of the type through the greater depth of surface soil and the accumulation of a little more organic matter. Where the Delavan silt loam laps against the Tazewell silt loam, south of

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the Mackinaw River, there is frequently found a slight depression containing a deeper, darker soil like that along the minor streams.

The natural drainage of this soil type is accomplished in part by the larger secondary streams, such as Big Crane Creek, and in part through the excellent underdrainage effected by the sand stratum below the loess. Tile drainage is rarely employed, surface ditches usually proving adequate for the disposal of surplus water.

The valley loess, from which this soil is derived, is believed to be a semiæolian, semilacustrine sediment formed by the deposition in the ponded waters of glacial streams of fine silt and clay particles carried into them from the surface of the receding glacial ice both by air and water currents. The limited portion of the valley loess studied in Tazewell County, while sufficiently characteristic to admit of thorough identification, is not extensive enough to form the basis of a theoretical consideration of the origin and relationships of this perplexing geological body. The immediate subsoils of both the Delavan and Tazewell silt loams are almost identical in texture, but, as has been indicated, the complete section to a depth of 15 or 20 feet differs materially. It is probable that the silty subsoil of the Delavan silt loam represents a reworked and redeposited fluvial phase of the Wisconsin till, which forms the deeper subsoil of the Tazewell silt loam.

The varied mineral constituents of the Delavan silt loam consist of finely divided and partly decomposed minerals brought into the area through glacial agencies from a number of sources and finally deposited in their present position through the intervention of river and lake conditions accompanying the closing stages of the Glacial epoch. It is a common characteristic of such deposits that the mineral matter composing them has not been so thoroughly decomposed chemically as that of residual soils, nor so thoroughly washed out and reduced to the state of chemical and mechanical simplicity as is the case with marine sediments. As a result, soils derived from glacial and loessial materials are apt to present, other things being equal, a favorable opportunity for the further preparation of plant food, because further decomposition of the silicate minerals present can render available various soluble compounds of the potash, lime, magnesia, and alumina occurring in these minerals. Soils derived from the loess are in consequence found to be well supplied with the mineral elements which enter into plant growth. In the case of the Delavan silt loam there is also present a good supply of organic matter, which helps to form a fertile and durable soil. The additional characteristics of a surface suited to easy cultivation and of good natural underdrainage have tended to render this soil type one of the most productive of the area.

The Delavan silt loam has been under cultivation since the early settlement of the county. Various fields have constantly produced crops of grass and grain considerably in excess of the average yield

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of the county and State. The fields have rarely been replenished by the addition of any form of fertilizer other than the feeding of stock on limited tracts. The average production of this type ranges from 35 to 50 bushels of corn per acre, 18 to 25 bushels of wheat, 35 to 40 bushels of oats, and about 1½ tons of mixed timothy and clover hay. During favorable seasons these yields are not uncommonly exceeded. As an evidence of the fertility of this soil, it may be stated that from 6 to 10 corn crops have been harvested in succession from single fields without fertilization and without noticeable diminution of the yield.

No change of crop adaptation need be suggested beyond the opinion that the feeding of more stock upon the farms located on this type would insure the maintenance of its present state of fertility for a long period of time.

The following mechanical analyses show the average texture of this soil type:

Mechanical analyses of Delavan silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.5 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6632	2 miles SW. of Delavan.	Brown silty loam, 0 to 18 inches.	3.00	0.30	0.90	0.72	0.98	8.86	69.42	18.82
6634	2¼ miles SW. of Green Valley.	Brown silty loam, 0 to 26 inches.	2.44	.26	1.20	.40	.80	5.04	69.26	22.74
6633	Subsoil of 6632......	Yellow silty clay, 18 to 40 inches.	.55	.10	.56	.42	2.70	13.02	73.22	9.56
6635	Subsoil of 6634......	Yellow silty clay, 26 to 40 inches.	.46	Tr.	1.00	.30	.74	6.90	75.82	15.08

MACKINAW GRAVEL.

The Mackinaw gravel consists of a gravelly soil and subsoil formed by the outcrops of pebble bands along the high bluffs of the Illinois River and along the margin of the Miami loam in the southwestern part of Tazewell County. This type consists of from 35 to 60 per cent of rounded or subangular gravel of glacial material of various sizes. The great majority of the pebbles are less than 2 inches in diameter. The fine earth mixed with the pebbles consists of sand and clay along the Illinois bluff and of a light sandy loam in the southwestern part of the county. This soil type is only found along the steep slopes where the glacial or alluvial gravels reach the surface and are carried down the slopes by rain wash and by active erosion.

The steep cliffs along the Illinois River above Pekin constitute the chief area occupied by this gravel. The low cliffs in Spring Lake

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Township give rise to only narrow bands of gravel, relatively unimportant. In the northern part of the county the more gently sloping portions of the cliffs are cultivated to various crops or maintained in pasture. Near the Woodford County line a few small vineyards are found on this type.

These areas should either be cultivated in vineyards or orchards or else reforested, as the continued plowing of the steeper slopes not only increases the erosion over this soil, but also enables the minor streams to cut their gorges back into the upland fields. The formation of permanent horizontal rows attendant on vineyard or orchard culture would reduce the rain wash to a minimum, while allowing the use of the land.

This type is for the most part uncultivated, as it has slight value for general farming. It might be adapted to grapes and peaches.

No mechanical analysis of this soil is given, since, aside from the large content of gravel, its fine-earth constituents are extremely variable.

YAZOO CLAY.

The Yazoo clay consists of a heavy drab clay loam, having a depth of 5 inches. This is underlain to a depth of 40 inches or more by a sticky yellowish clay. Below a depth of 5 or 6 feet there are found local veins of grayish sand.

In Tazewell County this soil type only occurs along the Illinois River bottoms. Its surface is very level, and is only indented by shallow sloughs and lake basins. Owing to the existing conditions, the Yazoo clay is inundated to a depth varying from 3 to 10 feet from December until the latter part of May. During the remainder of the year the surface is above water, but the subsoil is saturated below a depth of 2 feet.

The Yazoo clay consists of the finer sediments which are being deposited at the present time by the river, mingled with organic matter from vegetation growing in the bottoms. Very little of the Yazoo clay is under cultivation. The natural forest growth consists of elm, water maple, and a few scattered oaks and pecans. There is little underbrush, and the forest is open.

In order to render this soil available for agricultural purposes an extensive system of dikes and ditches must be constructed. The timber is not of sufficient value to pay for the clearing of the land. In the latitude of Tazewell County this soil is better adapted to wheat than to any other crop. The higher lying areas can be cultivated to spring wheat without recourse to extensive diking and ditching. Tile draining would not be necessary, since on exposure to the sun the surface cracks to a fine, granular "buckshot" condition, allowing the soil to a depth of 12 inches to become thoroughly drained.

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The area of Yazoo clay found in Tazewell County would amply repay the expenditure necessary to reclaim it.

The following mechanical analyses show the texture of this type:

Mechanical analyses of Yazoo clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6668	18 miles SW. of Pekin.	Drab clay, 0 to 9 inches.	1.55	0.14	0.80	1.32	6.60	10.06	52.32	28.74
6669	Subsoil of 6668......	Drab clay, 9 to 30 inches.	1.45	.48	1.20	1.52	12.96	19.40	44.58	19.68

YAZOO SANDY LOAM.

The surface 6 inches of Yazoo sandy loam consists of a fine yellow sand that is loose and friable when dry and packs to a compact surface when wet. It is underlain by a somewhat loamy yellow sand, extending to a depth of over 40 inches.

The entire area of Yazoo sandy loam in Tazewell County consists of about 96 acres, lying in the Illinois bottoms near Spring Lake. It comprises a bar of sandier material lying a little above the general level of the Illinois bottoms. This soil produces about 40 bushels of corn to the acre.

No analysis of this type is given, on account of its limited extent.

TAZEWELL SILT LOAM.

The soil of the Tazewell silt loam consists of a brown or gray silt loam containing some very fine sand and a small amount of clay. It has an average depth of from 16 to 18 inches. The soil grades down into a reddish-yellow subsoil, which becomes a lighter lemon color, sometimes mottled with gray, below 30 inches from the surface. The subsoil is a homogeneous mass of very fine sand, silt, and clay. There is much more clay present in the subsoil than in the soil. For this reason the subsoil is frequently known as yellow clay or yellow hardpan.

The Tazewell silt loam occupies the greater proportion of the upland region of Tazewell County. It is not found at any place in the alluvial area.

The surface of the Tazewell silt loam varies from a nearly level plain to a gently undulating or high-rolling upland. This type follows two moraine belts of the Wisconsin glaciation. One of these coincides

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approximately with the bluff line which extends from southwest to southeast across the county. The other crosses the extreme northeastern portion of the county. The highest crests of the moraines reach an altitude of about 350 feet above the Illinois River. They converge in the northern part of the county and diverge near the Mackinaw River, forming a broad, shallow depression. The Tazewell silt loam not only occupies the eastern area of the two moraine belts, but it descends their flanks toward the interior prairie country. It also occurs immediately along the banks of all of the major streams. It thus includes not only the greater proportion of the old upland timber belts, but also the higher hills encountered through the treeless prairie.

The natural surface drainage of the Tazewell silt loam is thoroughly established, with the minor exception of a few kettle holes located near the crest of the eastern moraine belt. The larger streams—chief among them the Mackinaw—have cut U-shaped valleys through the till. The wall slopes are steep and mark a sharp angle, not only with the upland, but also with the flat bottom lands. The streams in the northeastern part of the county form an exception to this rule. The steep slope from the crest of the bluff to the Illinois bottoms has allowed more active stream erosion and narrow V-shaped gashes have been cut.

The tilled lands of the Tazewell silt loam have been pretty generally underdrained by the use of tiling. This involves an expense of about $10 per acre.

The Tazewell silt loam has been derived, through the ordinary processes of weathering, from the low moraine hills and in part from the intervening till plains of the Wisconsin drift. Previously to the Wisconsin ice invasion this material formed a part of the surface of northern Illinois and Wisconsin and upper Michigan. It probably existed as glacial material deposited by earlier glaciation and as partly disintegrated rock. The glacial ice in its southward movement carried this material slowly to its present position, and after the accumulation of the Wisconsin glaciation the melting of the ice left behind a partly assorted mass of silt and clay, through which was scattered a great variety of erratic bowlders. Where the ice front halted through the stages of the retreat, this mass accumulated in the form of low hills known as a terminal moraine. At such points the bowlders are more numerous than elsewhere. The intervening till plains are built up more largely of the fine material carried within and under the ice, though some of the surface represents the accumulation of fine sediment borne by the water formed by the surface melting of the glacier.

This material forms a homogenous mass of partly decomposed mineral matter. Particles of quartz, of several varieties of feldspar, of mica, of hornblende, magnetite, and other minerals can be recognized

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with the microscope. The angular form of the minerals indicates that they have been reduced to their present fineness largely through mechanical crushing, rather than by chemical decomposition. All of the minerals are partly decomposed, but they still contain large amounts of lime, potash, and magnesia, which can be liberated slowly by progressive weathering to furnish a long-continued supply of the mineral elements necessary for plant growth. Thorough drainage and the use of stable manure will not only increase the fertility of the glacial soils by their direct action, but will also aid in the preparation of these minerals for plant use.

Corn, wheat, oats, and grass are the chief crops grown on the Tazewell silt loam. The yields vary considerably in different parts of the type. This is due in part to the variation in amount of organic matter found in the surface soil, but more largely to greater or less efficiency of cultivation. The best method of cultivation on this type is that which best preserves the organic matter already present, restores it where it has been lost, or furnishes it where it is naturally deficient. Narrow strips of this type located near the larger stream courses are particularly deficient in organic matter. The surface soil on such areas is more yellow and the depth to the subsoil is less than on the larger portions of the type. When cleared of their timber, these strips become naturally sodded over with blue grass, forming excellent pasturage. They also furnish desirable locations for the cultivation of orchard fruits. By careful farming, which should include stock raising and orcharding, this part of the Tazewell silt loam may be made as valuable as the great body of the type.

The present average yield of the Tazewell silt loam is from 40 to 60 bushels of corn, 20 to 25 bushels of wheat, 40 to 50 bushels of oats, and 1 to 1½ tons of hay per acre. With the exception of a small acreage of rye and barley, few other crops are produced on this soil. Nearly every homestead possesses a small orchard of different fruit trees, and numerous small vineyards have been set out. With the exception of one extensive orchard in the eastern part of the county, no systematic attempt has been made to derive any large part of the farm profits from fruit culture. The soil and climate are adapted to apples, pears, plums, cherries, grapes, and small fruits. A good sod is easily established, which prevents the soil from washing and which would promote a profitable dairy industry.

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The following mechanical analyses show the physical characteristics of this soil type:

Mechanical analyses of Tazewell silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6662	1¼ miles SE. of Pekin.	Brown silty loam, 0 to 8 inches.	2.21	0.70	1.80	0.60	0.76	5.31	75.84	14.72
6664	3 miles N. of Mackinaw.	Gray silty loam, 0 to 10 inches.	2.23	.20	.66	.52	.88	1.94	80.58	15.04
6660	1¼ miles NE. of Groveland.	Brown silty loam, 0 to 10 inches.	4.55	.72	1.30	.70	.86	2.04	76.00	18.20
6666	3¼ miles S. of Washington.	Brown silty loam, 0 to 16 inches.	2.70	.20	.54	.36	.52	1.74	70.04	26.44
6663	Subsoil of 6662......	Yellow silty clay loam, 8 to 40 inches.	.49	.64	.96	.48	.70	7.26	72.56	17.38
6667	Subsoil of 6666......	Yellow silty clay, 16 to 36 inches.	.80	.00	.54	.34	.72	1.54	75.08	21.76
6661	Subsoil of 6660......	Yellow silty clay, 10 to 40 inches.	1.35	.50	.90	.50	.56	2.20	68.78	26.24
6665	Subsoil of 6664......	Yellow clay loam, 10 to 36 inches.	.39	.00	.66	.28	.60	1.28	70.24	26.86

MIAMI BLACK CLAY LOAM.

The Miami black clay loam has a surface soil 20 inches or more in depth which consists of a sticky combination of clay, silt, and organic matter. When wet it is almost jet black in color, but the immediate surface on drying becomes gray or brown. The characteristic color is due to the presence of organic matter. Below 20 inches in depth the subsoil consists of a drab or yellowish clay, which is even more sticky and plastic than the soil. To a depth of 6 inches the surface soil is slightly granular and possesses a minute cubical structure.

The Miami black clay loam occupies the lower, more level areas through the central part of the till plain bounded on either side by the rolling moraine belts. The surface is nearly level or slightly hollowed out between ridges of the Tazewell silt loam.

A phase of this type having a blue clay subsoil coincides with an old swamp area that has been reclaimed through the construction of drainage ditches under the operation of the Illinois drainage laws. It represents a part of the territory which immediately after the close of the glacial period was occupied by a shallow lake. Into this lake the finer sediments were washed until it became so shallow that the marsh grasses secured a foothold. During this time the natural drainage of the country was becoming established, and the lake was transformed

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into a swamp by the cutting down of its natural outlet and by slow sedimentation around the margin. As a result a very homogeneous soil was formed, containing a considerable amount of organic matter mingled with the fine mineral detritus. At the time when the region was first occupied by settlers, other soil types could be brought under cultivation more readily than this swamp area, and its reclamation was only accomplished recently.

The headwaters of the few minor streams which drain the Miami black clay loam soil type occupy slight sags which resemble irregular artificial ditches rather than definite stream valleys. The natural drainage was poorly established or entirely lacking, and the Miami black clay loam has been brought under cultivation by extensive systems of drainage. No portion of the type is at present swampy or undrained.

This soil type owes its existence to the presence in this region of a series of recessional moraines between which a level floor of glacial till has caught the drainage and wash of the higher lands. As a result the finer sediments, chiefly clay, have slowly accumulated. The poorly established drainage failed to carry off excessive rainfall. Rank vegetation flourished during the dryer portions of the year and became intimately mingled with the fine sediments washed in from the surrounding hills during periods of considerable precipitation. At the time when the country was first settled the Miami black clay loam had but recently reached the final stage of soil formation. Its surface was covered by an abundant growth of prairie grass, though the moist condition of the soil and the annual prairie fires had prevented the trees from getting a foothold. As soon as cultivation had begun over the more rolling country, the idea of fertility commonly connected with black soils led to efforts for the utilization of this type. Its subjugation proved easy and the luxuriant growth of prairie grass was soon replaced by broad fields of corn and wheat. Further experience proved that this soil was eminently fitted for the production of corn, and this fact, together with the favorable climatic conditions, largely molded the course of agricultural development throughout the general region.

Corn is the principal crop raised on this type. Its average yield is between 50 and 60 bushels per acre, while the maximum crop attained is not uncommonly above 90 bushels per acre. Oats, wheat, and clover are subordinate crops in the rotation, producing yields somewhat above the general average of the county. Many fields located on this soil type have been cultivated for fifty years without the systematic addition of fertilizers and without any appreciable decrease in the amount of grain harvested. It would be difficult to suggest any crop better suited to this soil than corn or any soil better adapted to the production of corn than the Miami black clay loam.

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The following mechanical analyses of representative samples of this type give a clear idea of its texture:

Mechanical analyses of Miami black clay loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6648	1½ miles N. of Minier.	Black clay loam, 0 to 18 inches.	4.69	0.20	0.76	0.52	1.26	3.46	74.20	19.54
6644	1½ miles NE. of Tremont.	Black clay loam, 0 to 20 inches.	3.37	Tr.	.20	.20	1.10	5.32	72.44	20.64
6646	¾ mile SW. of Morton.	Black clay loam, 0 to 24 inches.	2.95	Tr.	.40	.26	.76	5.10	72.02	21.38
6647	Subsoil of 6646	Yellow silty clay, 24 to 40 inches.	.76	.12	.54	.14	.66	5.34	77.64	15.40
6645	Subsoil of 6644	Yellow and blue clay, 20 to 40 inches.	1.80	Tr.	.20	.34	.60	4.40	76.26	17.94
6649	Subsoil of 6648	Yellow silty clay, 18 to 36 inches.	1.67	Tr.	.70	.44	.98	3.76	75.68	18.32

DRAINAGE.

The Miami black clay loam and the Tazewell silt loam are generally underdrained by tile. Much more tiling is used on the former type than on the latter. The Miami black clay loam was brought under cultivation before tile drain came into general use, and open ditches were first employed to remove the excess of water. Later many of the tile-drain systems were laid in these ditches and covered. At present most of the farms located on this type are artificially underdrained. The use of the drain is not so general on the Tazewell silt loam, only parts of the various farms being treated.

In Spring Lake and Cincinnati townships an extensive open-ditch drainage system has been installed, draining the lower-lying areas of the Lintonia loam and the Peat. These ditches are from 24 to 30 feet wide at the top and from 8 to 10 feet deep. The system was constructed by a company which comprised as its stockholders the owners of the land to be benefited. This company constructed its own dredge boat, hired the workmen, and ran the drainage ditches at a cost of $12 per acre for excavation. A small acreage assessment is levied for the maintenance of the system. The original cost of the drainage has been more than offset by the increase in the value of the land. The peat land is at present used for the production of the ordinary crops of the region. The yields, while fair and ample to justify the expense of drainage, do not bring as good returns as could be secured from celery and onions.

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Similar areas situated more remote from markets are producing celery crops that range in value from $125 to $200 per acre annually, while the land is valued at from $300 to $400 per acre. This industry should be developed in the Tazewell County peat area.

A similar drainage system has reclaimed the large area occupied by the Miami black clay loam in southern Malone and Delavan townships. The expense in this case amounted to about $15 per acre and the value of the land affected has risen from a very low figure to $100 per acre.

Large tracts of land lying in the Illinois River bottoms still await drainage and diking operations to bring them under cultivation. The fertility of these lands is as great as that of any in the region, and though the expense of draining them will be greater than in the other instances the operations would be fully justified by the crop returns.

AGRICULTURAL CONDITIONS.

With the exception of a few square miles in the southwestern portion of Tazewell County, nearly every foot of the surface of this county not occupied by a town site is used for some agricultural purpose. Probably 80 per cent of the area is actually tilled, while the remaining 20 per cent, including the wooded stream bottoms and slopes, is used for pasture. The value of the farms varies considerably. Few farms located upon the Miami black clay loam or Delavan silt loam can be purchased for less than $125 per acre. On the Tazewell silt loam there is a greater range in price, but this is due in part to variations in the amount of improvement and greater specialization in farm products. This is true of other soil types, and it is believed that some of the soils at present held in least esteem could be made to exceed the present average value of the farm lands of the county by a more careful specialization in crops leading to an intensive system of cultivation. In general, the farm lands of the county are paying a good rate of interest upon their valuation, and they are considered a good security for loans by private persons and the local financial institutions.

The farm tenure varies in the different parts of the county. Probably more than 50 per cent of the farm land is occupied by the owner, while the remainder is held in long tenure by tenants who sooner or later expect to become owners of land within the county. Part of the tenant farms are leased for a cash rental, but the majority are worked on shares, 50 per cent to the owner and 50 per cent to the tenant being the usual basis. Other ratios are arranged, depending upon the amount of stock, implements, or seed furnished by the parties to the agreement. This arrangement is sufficiently satisfactory to secure a high class of tenants, experienced in cultivation and only lacking the capital necessary for the original purchase of the land they occupy.

The farms vary greatly in size. The quarter-section farm is com-

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mon, while farms comprising less than 80 acres are rare. Several proprietors own separate farms aggregating 1,500 acres or more. The average size of the Tazewell County farm is 125 acres.

The smaller farms are operated by the owner and his family, assisted during the press of work by daily or monthly labor, frequently performed through cooperation with neighbors. The larger farms are operated by the owners or a tenant in charge, who hires additional help by the year. The farm laborer, if married, usually occupies a neat tenant house. The younger, unmarried men secure board on the place or live at home. The greater part of the cultivation of the farm is done by horsepower, the level, gravel-free character of the soil giving horse machinery its greatest efficiency. Four-horse teams are usually employed in operating gang plows, disk harrows, grain drills, and force seeders. The cultivating is done with two-horse teams and wheel cultivators. The grain is thrashed and corn shelled by steam power, though some horsepower shellers are employed. In some cases thrashing associations are formed, a group of farmers owning the power machinery, which owners and tenants operate for exchange of labor.

Corn forms the basis of Tazewell County agriculture. Climatic and soil conditions favorable to this crop, coupled with the proximity of the Chicago market, have tended to this development. Oats occupy a second place among the grains. Clover and timothy hay are third in importance among farm crops. Wheat and rye, though raised, are of subordinate importance. Nearly every farm possesses a small orchard of apples, pears, and plums, while grapes and small fruits have been cultivated for home consumption during recent years. No large proportion of the fruit crop is sold outside the county. Small quantities of watermelons, sweet potatoes, and celery are raised in the southwestern portion of the county.

The existence of but two principal soil types upon the uplands, both well adapted to grain production, has led to the system of extensive rather than intensive farming which dominates the entire county. In consequence, although ten soil types are found in Tazewell County, the crop rotation practiced upon all is nearly identical. Two or more crops of corn are harvested before oats are sown as the next member of the rotation. With the oats clover is seeded. After one crop has been cut timothy is sown with the clover, and when that has been cut the sod land is again plowed for corn. The only adaptation of soils to a special crop is found where small tracts of the peat soil are producing celery and where the Miami fine sand is occasionally used for watermelons and sweet potatoes. The Tazewell silt loam and the Delavan silt loam are the only soils employed to any extent for dairying and stock raising.

The Illinois River is navigable above the northern limit of Tazewell

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County. Freight and passenger steamers run to St. Louis, with landings at Peoria and Pekin.

The county is well supplied with facilities for railroad transportation. The Chicago, Peoria and St. Louis, Chicago and Alton, Illinois Central, Lake Erie and Western, the Vandalia Line, the Big Four, and other trunk or branch railroads give communication with Chicago, St. Louis, and points east and west.

The highways of Tazewell County consist of dirt roads, chiefly laid out according to the Government land surveys along the section lines. The bluffs along the Illinois and Mackinaw rivers have necessitated some adjustment of grade to topography. Elsewhere the surface is so level that the rectangular road system is the rule. The roads are constructed by grading up the local material into turnpike form. Some road drainage is attempted, and a few miles of highway in Washington and Fond du Lac townships have been surfaced with gravel. The glacial gravel, which outcrops abundantly along the Illinois bluffs, and to a less degree along the Mackinaw and minor streams, constitutes an admirable material for surfacing the natural clay or loam roads of Tazewell County. In many instances the hauling distance from the gravel pit is slight, while in all cases the improvement of the road from the use of this gravel would be great. The taxable valuation of the land is sufficient to warrant a considerable expenditure for the improvement of the roads of the county.

Pekin and Peoria furnish the chief local markets for the farm products of Tazewell County. The distilleries, breweries, and glucose factories located at these points furnish a local demand for grain. The great proportion of the crop, however, is shipped from many small elevators along the principal railroads to the great central market at Chicago. The live stock is chiefly sent to the same place. Dairy products are either sold locally or in Peoria and Pekin. A considerable part of the butter, poultry, meats, and early vegetables used in the county is imported from outside.

The ease with which the grain crops can be cultivated has led to the adoption of a system of agriculture which is not self-supporting. The grain is continually sold from the field and a minimum amount of live stock fed in the region to restore the elements of plant food to the soils. The great natural fertility of the soils of the area has, so far, offset the tendency toward deterioration, and has established a false confidence in the advisability of this system of agriculture. It is probable that the present system might be continued beyond the limit of the lives of the present cultivators with only a slow decrease in the fertility of the soil. On the other hand, the course of agriculture in foreign countries and in the eastern part of the United States has shown that under this system the crop yields must gradually dwindle, and the same experience has shown that the fertility of any soil is much more easily maintained than restored.

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SOIL SURVEY OF CLINTON COUNTY, ILLINOIS.

By JAY A. BONSTEEL and PARTY, IN COOPERATION WITH THE ILLINOIS EXPERIMENT STATION.

LOCATION AND BOUNDARIES OF THE AREA.

Clinton County, Ill., comprises an area of about 490 square miles, (314,111 acres), located in the south central portion of the State. Carlyle, the county seat, is a town of about 2,000 population. It is situated on the Kaskaskia River, 45 miles east of St. Louis, Mo. The central portion of Clinton County is crossed from east to west by the Baltimore and Ohio Railroad and by the Southern Railroad. The Jacksonville and St. Louis Railroad crosses the northern portion of the county. Clinton County lies between the parallels 38° 30′ and 38° 45′ north latitude, and between the meridians of 89° 10′ and 89° 40′ west longitude. It has a total population of about 20,000, and its chief industries are agriculture and coal mining. (See fig. 13, p. 465.)

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Under the French occupation of the Illinois country no settlement was established in Clinton County, although it formed a portion of the hunting grounds which supplied the Illinois and Kaskaskia trading posts with furs. During French occupation land grants were made in the American bottoms in St. Clair County, which extended from the Mississippi River to the Kaskaskia, and perhaps thus included portions of Clinton County. Under British occupation the records of these grants were in part destroyed, and new grants were made to British citizens. These were finally confirmed by the new Government of the United States. In 1813 Congress granted the right of preemption, and immigrants poured in from North Carolina, Kentucky, and Tennessee. In 1808 a wagon road had already been laid out through Clinton County, and a blockhouse was erected in 1811, where this road crossed the Kaskaskia. The town of Carlyle was later located at this place.

Previous to the war of 1812 a few squatters had settled within the borders of Clinton County. For the most part these moved to points of greater safety during the war. The first regular land entries were made in September, 1814, by John Journey, Charles Cox, and James McCracken, in what is now Sugar Creek Township. About 1818 Car-

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lyle was laid out as a "boom town" by Charles and Thomas Slade, merchants from New England.

Most of the early settlements were located in the timber belts near the stream courses, for security against Indian attacks. The prairies were occupied later, when this danger had passed away. By 1820 there had been preempted within the county 30,000 acres of land, and corn, wheat, meat, and live stock were exported. During the next ten years corn sold for 12½ to 15 cents a bushel; wheat, for 37½ to 50 cents a bushel; pork, 1½ to 2 cents a pound; beef, at about the same price, and live stock at correspondingly low prices.

Oxen were employed in farm work to a greater extent than horses, even the early grist mills of the region being operated by them.

Clinton County has remained preeminently an agricultural county. Corn has given place to wheat, while orchards of apples and peaches have been introduced.

CLIMATE.

The normal temperature and precipitation are indicated in the appended table, giving the records of three Weather Bureau stations in surrounding counties. Greenville lies about 15 miles north of the area, in Bond County; Mascoutah, about 5 miles west, in St. Clair County, and Plumhill about 7 miles south, in Washington County. Within Clinton County itself there is no station.

Normal monthly and annual temperature and precipitation.

Month.	Temperature.			Precipitation.		
	Greenville.	Mascoutah.	Plumhill.	Greenville.	Mascoutah.	Plumhill.
	°F.	°F.	°F.	Inches.	Inches.	Inches.
January	28.8	31.3	31.2	2.90	2.82	2.62
February	31.0	31.3	31.7	3.36	3.21	3.05
March	41.0	42.5	42.8	3.58	4.06	4.46
April	55.4	55.4	55.2	4.16	4.11	3.42
May	63.8	63.9	65.5	5.03	4.97	3.90
June	73.3	75.6	73.3	4.91	4.31	4.47
July	77.8	78.9	78.3	3.53	2.89	3.87
August	75.6	76.4	76.3	2.72	2.33	2.66
September	68.7	70.2	69.9	3.32	3.27	3.42
October	56.4	56.2	56.8	2.60	1.98	2.09
November	41.7	42.1	43.5	3.85	3.55	3.22
December	34.1	35.3	34.7	3.01	2.35	3.04
Year	53.9	54.9	54.9	43.03	39.76	40.27

The average date of the last killing frost in spring at Greenville is April 26, at Mascoutah April 25, and at Plumhill April 14; while the first destructive frost in fall occurs on October 9, October 10, and October 13, for the respective stations in the order given.

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PHYSIOGRAPHY AND GEOLOGY.

Clinton County consists of a level prairie interrupted only by the broad bottom lands along the principal stream courses and by the scattered hills formed by the morainal deposits of the Illinois glaciation. The lowest points of the prairie are in the southeastern portion of the county, though the surface slope toward the northwest is so gradual as to be almost imperceptible. The morainal hills vary in extent from a few acres to masses covering 2 or 3 square miles. None of them attain an elevation greater than 250 feet above the surrounding plain. These hills are conical or lenticular in shape. The Kaskaskia River and its tributaries have cut broad, shallow valleys through the prairies. The streams of Clinton County are at present engaged in building up their flood plains, and only short, minor streams are cutting down their beds.

Below Carlyle the Kaskaskia bottom is extensively cultivated, and its soils give the best yields in the county. The Shoal Creek bottoms are also cultivated to some extent, otherwise the stream bottoms of the county are for the most part forested. The timber comprises several varieties of oak, water maple, hickory, elm, cottonwood, and sycamore. The margins of the prairie adjoining the stream bottoms were also originally forested and have only been partially cleared. The prairie proper at the time of the first settlement supported only scattered groups of cottonwood and maple. The morainal hills were for the most part heavily timbered. At present they are almost all cleared.

The consolidated rocks which form the basal foundation of Clinton County consist of sandstone, limestone, and shale of the Upper Coal Measures. Bituminous coal is reached at a depth of about 350 feet in the western part of the county. A gentle dip to the southeast carries this coal to a depth of about 500 feet near the eastern boundary. The principal coal mines are located near Trenton and Breese. The output is chiefly used by the railroads crossing the county. The rocks of the Coal Measures are overlain by the gravelly yellow and blue till of the Illinois glaciation. This material reaches the surface only in stream cuts and railroad excavations, its thickness varying considerably. Under the prairie the average thickness of the Illinois till is about 20 feet. In the morainal hills its depth increases to about 200 feet. The till proper is overlain by 2 to 6 feet of mottled, gray, and yellow silty clay, which forms the common subsoil of the prairie region. The surface soil of the prairie region consists of 8 to 24 inches of very fine sand and silt. There is no distinct boundary line between the gravelly till and the overlying silty clay. The line of demarcation between this silty clay and the surface loam is fairly sharp in all cases. Along the western border of the county the silty clay becomes more yellow

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and closely resembles typical loess. Its demarcation from the underlying till is also sharp in this region.

The gravel of the Illinois till varies from small quartz pebbles of the size of a pea to bowlders of sandstone, limestone, granite, and diabase, having a weight of 1 or 2 tons. Gravel the size of a hen's egg predominates over the finer or coarser material. The matrix in which this gravel is found consists of a hard, plastic yellowish clay. Yellow stains of hydrated oxide of iron are numerous, and in some instances well-developed nodules of crystalline aggregates of gypsum are associated with the iron stains. Fantastic calcareous concretions are also found in the till. In some localities the till is jointed and crusts of hydrated oxide of iron have formed along the joints. The yellow silty clay contains no pebbles. Near its surface it is subject to the accumulation of salts of iron and lime, which form a hardpan of quite general distribution throughout the prairie region. This silty clay overlies the till over both the prairie region and the highest summits of the morainal hills. It resembles loess to a limited degree, but differs materially from the typical loess.

Since the close of the Glacial epoch the principal streams of the region have reworked the materials derived from the upland, building up alluvial bottoms, which, owing to the sorting power of moving water, are more varied in composition and texture than the uplands from which the material was derived. The Kaskaskia River, being the most powerful stream flowing through the county, has given a wider range to the sediments of its bottom lands than any of the minor streams.

SOILS.

The surface of Clinton County is occupied by seven distinct types of soil. Four of these are found in the stream bottoms, two upon the prairies, and one upon the morainal hills. The differences that exist between these soils are due chiefly to texture, topographic position, and drainage. Thus in the bottom lands all of the soils are subject to periodic overflow unless protected by levees. Owing to differences in texture four distinct varieties of soil may be identified, ranging from a yellow sandy loam found along the front lands of the Kaskaskia River, to the sticky, plastic clays of the lower sloughs locally known as "gumbo." The depth at which these bottom lands are permanently saturated with water also constitutes a difference between the types.

The chief factor in the control of crop production is the maintenance in the soil of the exact amount of water required to carry plant food into solution and to furnish the large amount of moisture which must be exhaled by each plant during the growing season. The maintenance of this moisture in the soil and the control of its circulation depend first upon the size of the individual soil particles. The relative size of the particles of a soil is called the texture of the soil. The

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arrangement of these particles in space and the consequent proportion and distribution of pore space in the soil constitutes the structure of the soil. The two are closely related. In addition natural drainage and the proximity of the water table to the surface affect the supply and circulation of soil moisture.

The texture of the soil is determined by grading the different-sized particles according to a definite scale. The finest particles, which give plasticity to the soil, are called clay. Those next coarser constitute the silt, and the particles large enough to be distinguished by the naked eye form several grades of sand and the fine and coarse gravel. The mechanical analyses given with the soil types thus express the textures of the various soil types, establishing clays, loams, sandy loams, etc., according to variation in texture.

The areas of the different types found in Clinton County are given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Marion silt loam	172,480	54.9	Yazoo clay	5,376	1.7
Miami silt loam	57,472	18.3	Yazoo sandy loam	2,176	.7
Waverly silt loam	42,112	13.4	Total	314,111	
Kaskaskia loam	24,576	7.8			
Edgerton silt loam	9,920	3.2			

EDGERTON SILT LOAM.

The Edgerton silt loam consists of a very fine yellowish sandy and silty loam soil having a depth of about 12 inches. This is underlain by a massive yellow silty clay subsoil. The thickness of the immediate subsoil usually exceeds 5 or 6 feet, and it rests upon the gravelly yellow or blue clay of the Illinois till. The surface soil is friable and powdery when dry, but packs to a firm surface when wet. It forms clods if cultivated before becoming sufficiently dry. The line between the soil and the subsoil is quite distinct, being a natural division between two classes of material rather than an artificial boundary established by cultivation. The subsoil is a dense, massive, uniform body of reddish-yellow silty clay. The color is darker near the surface, grading down to a lighter yellow with increased depth. There is no pronounced mottling.

The Edgerton silt loam occupies scattered areas in the central and western parts of Clinton County. This type is almost coextensive with the rounded hills and long low ridges which interrupt the almost absolute level of the prairie region of the county. These hills represent the morainal deposits of the Illinois glaciation. They are roughly oval in form and rarely exceed an elevation of 125 feet above the level of the surrounding prairie.

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Owing to the elevated position occupied by the Edgerton silt loam, it possesses the best natural drainage of any of the soil types encountered in the area. This drainage is accomplished in part by seepage through the soil and subsoil and in part by surface flowage. For this reason the Edgerton silt loam is somewhat subject to soil wash along the steeper flanks of the hills and some care is required to prevent the formation of gullies.

The Edgerton silt loam forms one phase of the extensive loesslike deposits which overlie the gravelly till of the Illinois glaciation. Throughout its extent this material consists of very fine-grained sediments, whose origin and method of deposition have not been definitely determined by students of geology. It is believed, however, that it has been brought to its present position in part by the agency of wind and in part by water. The Edgerton silt loam is marked by the absence of the iron nodules and hardpan so prevalent in the prairie. This characteristic, together with its advantage of drainage, makes it one of the most desirable soils of Clinton County. It produces from 15 to 20 bushels of wheat, from 25 to 35 bushels of corn, about the same quantity of oats, and an average of 1 ton of hay per acre. Owing to the absence of hardpan, deep-rooted crops like clover and corn can thrive better upon the Edgerton silt loam than upon the prairie.

Many orchards of apples and peaches are located upon this type, and where properly cared for, the trees are thrifty and produce good yields. In too many instances the orchards are not properly cultivated or fertilized, and an attempt is made to produce grain or other crops between the rows even after the trees have reached the bearing age. The Edgerton silt loam is also suited to the production of grapes, cane fruits, and strawberries.

The following mechanical analyses show the uniform texture of this soil as it occurs in different localities:

Mechanical analyses of Edgerton silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6750	2 miles SE. of Breese.	Yellow silty loam, 0 to 9 inches.	1.44	0.16	0.40	0.36	0.72	4.42	81.06	9.88
6748	3½ miles SW. of Keyesport.	Yellow fine sandy loam, 0 to 9 inches.	1.44	.16	.76	.82	1.72	5.34	76.64	14.44
6751	Subsoil of 6750	Yellow silty loam, 9 to 40 inches.	.46	Tr.	.16	.16	.70	3.56	78.52	16.86
6749	Subsoil of 6748	Yellow silty clay, 9 to 40 inches.	.25	.20	.60	.56	1.11	3.84	70.86	22.80

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MARION SILT LOAM.

The Marion silt loam is marked by a gray or yellowish-white surface soil consisting almost entirely of very fine sand or silt. This soil varies considerably in depth in different parts of the county, the average for the entire area being 12 inches. The soil is underlain by a white to ash-colored silt, locally mottled with stains of hydrous iron oxide or containing closely packed concretions of that material. This layer may be an inch or two in thickness, in which case it is hardly noticeable, or it may form a massive stratum nearly a foot thick. It is then called hardpan. The real subsoil of the Marion silt loam consists of a hard, stiff silty clay of mottled appearance, the prevailing colors being gray, light yellow, and reddish yellow. Where this subsoil is exposed in natural or artificial cuts, the shrinkage due to drying causes it to check into irregular angular fragments consolidated to a stony hardness.

The Marion silt loam occupies the level prairie land comprising the eastern three-fourths of the county. It is interrupted only by the low morainal hills, which are occupied by the Edgerton silt loam and by the broad, shallow valleys of the principal streams of the region. There are few minor streams draining the prairie land, and the precipitation which falls upon its surface is carried off by artificial ditches or by seepage through the soil.

The materials forming the Marion silt loam, like those of the Edgerton silt loam, are of loessial origin. The total thickness of this material is only 10 or 12 feet throughout the prairie region. It directly overlies the Illinois till, with no pronounced break between the two classes of material. The only constant difference between them is marked by the presence of gravel in the till.

The most important feature of the Marion silt loam is the presence at varying depths between the soil and subsoil of the iron hardpan already mentioned. This hardpan is found in all stages of development, from a faint ocherous stain to a compact mass of small-sized iron gravel embedded in the silt and clay. Concretions of calcium carbonate and crystals of calcium sulphate (gypsum) are associated with the iron nodules. The exposed edges of this hardpan, frequently encountered in ditches, are coated with stalactitic layers of clay hardened into a compact mass by lime salts until the surface resembles the incrustations of calcareous tufa frequently encountered in the vicinity of hot springs.

The Marion silt loam is devoted chiefly to the production of winter wheat. The yield in Clinton County is from 8 to 12 bushels per acre. The oats yield about 25 bushels per acre, and hay, chiefly timothy, about three-fourths of a ton per acre, while only sufficient amounts of corn and potatoes are raised for consumption on the farm. Wheat

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has been the principal crop raised on this type of soil since the settlement of the county. The shallowness of the soil and the extensive development of hardpan throughout this type interfere with the production of deep-rooting crops like corn and clover and restrict the crop rotation which may be practiced on this soil. Fruit trees thrive on the Marion silt loam. Apples are produced to better advantage than peaches. At present nearly every farm possesses a small orchard of different fruits intended chiefly for home use. These orchards are usually poorly cared for, though a few of the farmers located on this type have given special attention to orcharding with considerable success.

With proper underdrainage peaches and cane fruits could be successfully cultivated, as well as apples and pears. The orchard industry should be more systematically developed, as the climate and proximity to markets favor this industry.

The following mechanical analyses show the physical texture of the soil and subsoil of this type:

Mechanical analyses of Marion silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.5 mm.	Silt, 0.05 to 0.005.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6738	5 miles SW. of Carlyle.	Very fine sandy loam, 0 to 10 inches.	1.17	0.56	1.14	0.64	0.72	7.04	79.88	9.00
6736	1½ miles S. of St. Rose.	Gray silty loam, 0 to 15 inches.	1.87	.14	.96	.56	1.06	8.42	77.88	10.60
6734	1 mile NE. of Huey.	Very fine sandy loam, 0 to 18 inches.	1.78	.40	1.02	.76	1.48	4.50	77.86	12.44
6737	Subsoil of 6736	Silty clay, 15 to 36 inches.	.39	.12	.52	.46	1.02	10.42	67.62	19.84
6735	Subsoil of 6734	Silty clay, 18 to 36 inches.	5.82	.88	1.78	1.10	1.96	10.70	60.88	22.40
6739	Subsoil of 6738	Hardpan, 10 to 40 inches.	.36	.48	1.44	.88	.98	5.06	68.64	22.52

MIAMI SILT LOAM.

The surface soil of the Miami silt loam consists of 18 inches of brown silty and fine sandy loam. It is somewhat sticky when moist, from the presence of a small amount of clay. This soil grades downward to a yellowish-brown silty clay, which is decidedly stiff and tenacious. In some cases the subsoil contains small amounts of iron concretions below 36 inches, but no pronounced hardpan is found in this type.

The Miami silt loam occupies the gently rolling prairie in the west-

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ern and northwestern part of Clinton County. The variations in elevation in this prairie are slight, but they are sufficient to give a better natural drainage than is found farther eastward. This type is also drained by a greater number of small streams than is the Marion silt loam.

The Miami silt loam is derived from loesslike materials covering the till of the Illinois glaciation. It differs from the other soils in the county similarly derived by possessing a greater depth of surface soil, a larger proportion of organic matter in this surface soil, and by the almost total absence of hardpan between soil and subsoil. On account of these characteristics it is more fertile and more retentive of moisture during the growing season than the Marion silt loam.

Wheat and corn are both produced to advantage on this soil, while clover and timothy yield fair crops. The average yield of wheat per acre on this type in Clinton County is from 18 to 20 bushels, that of corn from 40 to 45 bushels, and of hay from 1 to 1½ tons. Many small vineyards and orchards of apples and peaches are located on this soil type, furnishing a supply of fruit for home consumption. On this type dairying is carried on to a greater extent than on others in the county, though this is in part due to proximity to the St. Louis market, to which the bulk of the milk is shipped. The remainder is made into butter or used for the manufacture of condensed milk.

The Miami silt loam is the most productive soil in Clinton County outside of the bottom lands. The following mechanical analyses show the texture of this type:

Mechanical analyses of Miami silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6752	1½ miles NW. of Trenton.	Silty loam, 0 to 18 inches.	1.64	0.52	0.56	0.44	0.50	6.64	82.60	8.74
6753	Subsoil of 6752......	Silty loam, 18 to 40 inches.	.62	.56	.60	.36	.60	4.80	74.58	18.46

WAVERLY SILT LOAM.

The surface soil of the Waverly silt loam consists of about 10 inches of brown silty loam. It is underlain by a silty loam subsoil, grayish or yellowish in color, containing a larger proportion of clay. This soil occupies the greater proportion of the bottom lands along the minor streams and the higher portions of the Kaskaskia River bottom. Near

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the low cliff line which borders these bottoms the surface of this soil slopes gently toward the streams. Elsewhere it is nearly level. The Waverly silt loam is subject to overflow during the spring freshets, and even during the drier periods of midsummer the subsoil is usually saturated at a depth of 4 or 5 feet. The surface of the soil is usually sufficiently elevated above the normal stream level to insure fair drainage during the growing season, while, on the other hand, it is near enough the permanent water table to furnish an ample supply of moisture through capillary circulation. It only requires a small amount of diking for protection against unseasonable floods to constitute this soil one of the most valuable occurring in Clinton County.

The Waverly silt loam owes its origin to the accumulation of sediments washed down from the adjoining prairies and from areas outside the county near the headwaters of the streams along which it occurs. It thus consists of reworked silty material derived from the upland, mingled with organic matter and clay. It combines the usual advantages of alluvial origin and a favorable texture with a position favoring the maintenance of an adequate water supply during the growing season. At present fully 75 per cent of this type is clothed with a forest growth of oak, water maple, hickory, and cottonwood, with a few scattered pecan trees. The remaining 25 per cent is cultivated almost exclusively to corn. The average yield is about 40 bushels per acre. The value of the timber in the forested portions is hardly sufficient to offset the expense of clearing. No systematic attempt has been made toward diking or draining the minor stream bottoms, although the crop returns from the cultivated portions indicate that the best corn lands of the region are located here. It is in these localities that the most thorough control of the water supply could be obtained.

The following mechanical analyses show the texture of the Waverly silt loam:

Mechanical analyses of Waverly silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6744	2½ miles SW. of Keyesport.	Gray silty loam, 0 to 12 inches.	1.80	Trace	0.42	0.56	2.18	4.46	77.56	14.52
6746	4½ miles S. of Junkersville.	Gray silty loam, 0 to 14 inches.	2.23	.54	2.04	.98	1.34	10.60	67.54	16.74
6745	Subsoil of 6744......	Mottled silty loam, 12 to 40 inches.	.36	.22	1.02	.72	4.38	8.30	72.06	13.20
6747	Subsoil of 6746......	Mottled silty clay, 14 to 36 inches.	.55	.40	1.10	.54	1.16	3.58	64.30	28.92

KASKASKIA LOAM.

The surface soil of the Kaskaskia loam consists of about 8 inches of a brownish loam containing some medium sand. The subsoil is a gray loam somewhat mottled and iron-stained. It usually contains more sand than the surface soil, though near the borders it is apt to become quite clayey. This soil occupies large areas in the Kaskaskia River bottom and along the lower courses of the larger tributary streams. Its surface is usually level, though small, minor depressions indicate old stream channels.

The Kaskaskia loam, unless diked, is subject to annual overflow, and during the greater part of the season the water table stands within 3 feet of its surface. Broad, open ditches are at present employed for the drainage of this soil type. It is sufficiently porous for the practice of tile drainage. A small portion of this type is included within the Santa Fe drainage district.

The Kaskaskia loam is an alluvial soil, which owes its origin to oft repeated overflows of the streams along which it is found. It is composed of mingled sand, clay, silt, and organic matter. Outside of the diked areas it is receiving fresh accessions of material annually. It is abundantly fertile. Its texture is favorable both to easy drainage and easy cultivation, and it only requires underdrainage and protection from overflows to make it one of the most productive and valuable of the soils of the county.

At present two-thirds of its surface is covered by an open forest of oak and water maple. The cultivated areas of the Kaskaskia loam produce about 25 bushels of wheat per acre, 50 bushels of corn, about the same of oats, and good yields of clover and timothy hay.

The following table gives the mechanical analyses of the Kaskaskia loam:

Mechanical analyses of Kaskaskia loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6742	3 miles S. of Germantown.	Brown loam, 0 to 8 inches.	2.15	0.62	1.48	1.14	5.38	8.36	67.56	15.98
7528	7 miles S. of New Baden.	Brown loam, 0 to 12 inches.	2.69	.20	2.38	4.52	3.30	4.88	57.06	28.00
6743	Subsoil of 6742......	Mottled gray loam, 8 to 36 inches.	.70	1.10	1.54	.98	3.60	5.68	64.68	22.52
7529	Subsoil of 7528......	Heavy drab silty clay, 12 to 36 inches.	1.00	.72	2.94	5.86	2.70	3.62	60.98	23.14

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YAZOO SANDY LOAM.

The front lands along the Kaskaskia River, particularly near the large bends, are occupied by a yellow fine sandy loam having a depth of about 12 inches. This is underlain to a depth of 40 inches or more by a grayish-yellow sandy loam, slightly mottled with stains of hydrated iron oxide. The largest single area of this soil is found in eastern Santa Fe Township, where the Kaskaskia River swings to the southwest.

The surface of this type is nearly level and slightly elevated above the general surface of the bottom lands. It is subject to frequent overflow, but its advantage of elevation, its location near the deeper stream channels, and its porous nature allow of rapid drainage after the subsidence of the water. This soil has been accumulated through the deposition of the coarser material carried by the streams at time of floods. As the currents break from their usual channels their force is first checked near the banks. Since the power to carry sediments varies with the velocity of the current, the coarser sediments are almost immediately deposited in the form of sand bars or sand plains. Successive inundations increase the elevation and area of these deposits. Some organic matter is constantly mingled with the sand and silt, and the whole is built up gradually into a sandy loam.

The Yazoo sandy loam is devoted almost exclusively to the production of corn. The yield varies considerably with seasonal conditions, the average production falling between 30 and 45 bushels per acre. If properly protected by dikes this type is well adapted to the production of truck crops, such as early Irish potatoes, sweet potatoes, watermelons, tomatoes, cantaloupes, sugar corn, and green peas. The largest area found in Clinton County is crossed by one of the principal railroads, so that market facilities can be easily obtained.

The following mechanical analyses show the texture of this soil:

Mechanical analyses of Yazoo sandy loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6754	4¼ miles SE. of Junkersville.	Fine sandy loam, 0 to 9 inches.	1.72	0.42	1.40	3.44	15.66	9.44	55.84	13.80
6755	Subsoil of 6754	Sandy loam, 9 to 36 inches.	.67	.44	1.40	2.92	14.24	7.98	56.98	15.96

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YAZOO CLAY.

The surface 5 inches of the Yazoo clay consists of a sticky brown or drab clay loam, easily distinguished by its cracking into irregular angular pellets and granules when thoroughly dried. This surface soil is underlain to a depth of 40 inches by stiff plastic drab or yellowish clay. The soil is commonly saturated with water below 2 feet.

In Clinton County the Yazoo clay occupies small areas of depressions in the broader bottom lands. The hollows mark the position of former stream channels or little lake beds. They are usually of small extent, though one large one exists southwest of Keyesport in the Kaskaskia bottom. This soil is locally known as "gumbo." On account of its dense, fine-grained character and low-lying position this soil is poorly drained, and it is almost entirely uncultivated.

Like the other soils of the bottom lands, the Yazoo clay is of alluvial origin. At times of overflow that portion of the water left behind after the recession of the flood has accumulated in the low depressions and slowly deposited the finest sediments carried by the streams. These areas are thus occupied by the most plastic clay found in the county. The Yazoo clay is best adapted, when properly drained, to the production of wheat and grass.

The following mechanical analyses show the large amount of clay present in this soil:

Mechanical analyses of Yazoo clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6756	3¾ miles E. of Junkersville.	Drab clay loam, 0 to 6 inches.	2.01	0.60	0.76	0.34	2.86	5.20	66.14	24.50
6758	2 miles S. of Keyesport.	Drab clay, 0 to 6 inches.	4.10	.42	1.12	1.14	3.46	3.00	52.78	38.06
6757	Subsoil of 6756......	Drab clay, 6 to 40 inches.	.88	.78	.74	.34	1.86	5.26	68.00	22.86
6759	Subsoil of 6758......	Drab clay, 6 to 36 inches.	.94	.06	.34	.36	1.56	1.48	54.80	41.06

AGRICULTURAL CONDITIONS.

The condition of agriculture in Clinton County varies considerably, depending upon the character of the soils found in different parts of the county. The level prairies of the eastern and central portion have been farmed to wheat since the first general settlement of the county under the early preemption laws of the United States Government.

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Oats, corn, rye, grass, and potatoes are subordinate crops. The yield of wheat varies from 8 to 10 bushels in unfavorable seasons to a maximum of about 15 bushels per acre. The farms are operated chiefly by the owners, though some of them are leased for a money rental or a share of the products. The average size of the farms throughout the county is about 100 acres. Usually farm operations are carried on by the owner or tenant, aided by the members of his family. Extra hands are hired during harvesting.

In the bottom lands and on the Miami silt loam corn and wheat are raised extensively; otherwise the agriculture differs little from that of the prairie lands to the east.

With the first settlement of Clinton County small apple orchards were planted on each farm, and these have been renewed and increased from time to time, more for the supply of the home market than for exportation. During the last fifteen years several extensive orchards of peaches, pears, and apples have been set out for the production of fruit on a commercial scale. The pears and apples have proved more profitable than the peaches. The importance of clean cultivation in the young orchards and of careful pruning and spraying have not been sufficiently understood. These attempts, while not fully successful, have demonstrated the possibility of profitable fruit culture within the area. The climatic conditions are favorable to fruit culture, the area is well located with regard to transportation facilities, and the results already achieved demonstrate that the presence of the iron hardpan in the Marion silt loam is not detrimental to the thrifty growth and abundant productivity of apple and pear orchards located upon this type. On the other hand, the hardpan does preclude the profitable cultivation of corn, clover, and other deep-rooting crops and reduces the yield of wheat, oats, and timothy. Peaches, grapes, and cane fruits can be successfully raised on the Edgerton silt loam and the Miami silt loam. None of the bottom lands are adapted to the production of perennial fruit crops. If protected from overflow strawberries could be raised successfully on the Yazoo sandy loam.

The great uniformity of the soil of the upland portion of the county has led to a uniformity in crop production. The distinction recognized between the Miami silt loam and the Marion silt loam is that corn is a certain crop on the former and a very uncertain crop on the latter. The bottom lands are also recognized as better adapted to corn than the greater part of the prairie. Otherwise there is very little adaptation of crop to soil in Clinton County.

The usual equipment of the farm in Clinton County consists of a frame dwelling house, horse barn, and outbuildings. Grain is thrashed and the straw stacked in the field, the grain being shipped almost immediately. A large proportion of the hay is stored for feeding in the stock barn and the remainder is stacked in the field. Stable manures

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are used and some straw is employed for mulching potato fields and ultimately plowed under. The remainder of the straw is fed or sold to paper mills. No commercial or mineral fertilizers are used in the county.

The live stock upon the farm consists of work horses or mules and several milch cows. Considerable milk is exported from the county and the remainder is manufactured into butter. No cheese is made.

When it is considered that Clinton County is located within 50 miles of the St. Louis market, that it is crossed by several trunk lines of railroad, that it has been settled for nearly a century, and that it possesses a considerable variety of soils and a large supply of bituminous coal, easily accessible, it becomes evident that the opportunities for agricultural development have not been adequately appreciated up to the present time. Market gardening and trucking are almost unknown in the county, though the climate, soil, and proximity to markets favor these branches of farming. Likewise the production of fruit has only been attempted successfully by a few of the more enterprising farmers. Underdrainage by the use of tile is almost unknown in the county, though the greater part of the prairie land requires such treatment. The bottom lands have only been partly cleared and, though their soils are the most fertile in the county, not over 5,000 acres are properly diked and drained.

Clinton County presents an excellent field for both experimental and practical work in the reclaiming of lands subject to overflow, in the renovating of prairie lands injured by the presence of hardpan, and in the general improvement of cultural methods. These are needed at present more than the introduction of new crops or the exploitation of new markets.

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SOIL SURVEY OF ST. CLAIR COUNTY, ILLINOIS.

By GEORGE N. COFFEY and PARTY, IN COOPERATION WITH THE ILLINOIS EXPERIMENT STATION.

LOCATION AND BOUNDARIES OF THE AREA.

St. Clair County is one of the southwestern counties of Illinois, lying between 38° 13′ and 38° 40′ north latitude and 89° 42′ 30″ and 90° 16′ west longitude. The county is of irregular outline, with a maximum length both north and south and east and west of about 30 miles. Clinton and Washington counties form its eastern boundary, Randolph and Monroe counties lie to the south, Monroe County and the Mississippi River border it on the west, and Madison County bounds it on the north. It contains an area of 650 square miles, or 415,872 acres. The Mississippi River washes its western border for a distance of 13 miles. Across the river lies the city of St. Louis—one of the largest markets in the country. Here, even in the early history of the county, the farmers found a ready market for their products, and this fact has contributed in no small degree to make St. Clair County one of the leading agricultural counties in the southern portion of the State. (See fig. 13, p. 465.)

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

St. Clair County was once inhabited by the race known as the Mound Builders, as is evidenced by fifty or sixty mounds that still remain as monuments to their occupation. When the French Jesuits first visited this region the country was inhabited by tribes of the Illinois Indians, branches of the great Algonquin family. Agriculture received little attention at their hands, although small crops of corn, beans, potatoes, and peas were grown. The early settlers did not have a great deal of trouble with these Indians, although some stubborn and bloody battles were fought before the possession of the rich lands was abandoned to the whites.

The county of St. Clair, the oldest in the State, was organized in 1790 out of a part of the Northwest Territory. As originally constituted it embraced all of the State of Illinois south of the Illinois River. The history of its settlement begins, however, almost a hundred years before the United States existed as an independent nation. The first settlement within its present borders was made at Cahokia by French

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Jesuits about the year 1686. This place was selected as a missionary station by the Jesuits. Indian traders soon followed, and the infant settlement was placed upon a substantial and permanent basis. The next settlement was at Prairie du Pont in 1760. The only American settlement within the present limits of the county at the beginning of the nineteenth century was at Turkey Hill and contained about 20 persons. Very soon, however, the American settlements began to increase rapidly, and in a few years the log cabin of the pioneer was to be seen in every part of the county. The settlers came principally from the South and from Pennsylvania.

In 1829 German immigrants began to arrive in considerable numbers, and the influx continued, until to-day they form the largest element in the population.

The first settlers found the uplands diversified with timber and prairie, the latter usually being small and found chiefly in the central and eastern portion of the county. The alluvial bottoms were generally timbered, although small prairies existed there also. The settlements were usually situated upon the margin of a prairie, near some stream or bayou.

The early settlements of the French and American pioneers differed very materially in character. The French settlements were in the form of small, compact, patriarchal villages. A long, narrow strip of land in the "common field," which extended from the river to the bluff, was allotted to each villager, the amount depending upon the size of his family. The "commons" furnished pasturage for the stock of the entire village. The American pioneers settled upon separate farms, often 3 or 4 miles apart.

Agriculture was at first carried on only to a very limited extent. The early settlers usually plowed the ground with wooden plows drawn by oxen yoked together by the horns. The wheat grown at first was almost all spring wheat, but later winter wheat was more largely introduced, and the growing of spring wheat was gradually discontinued. The wheat was cut with a sickle, winnowed with a sheet, and sold for about $1 a bushel. The growing of corn gradually increased until considerable quantities were shipped in flatboats to New Orleans, along with cattle and hogs raised for the same market. Irish potatoes produced a sure and abundant crop. Hay was cut from the prairies or grassy groves in the timber. Only small quantities of butter and cheese were produced, scarcely enough for home consumption. Apples and pears and a few apricots and peaches were cultivated. Cotton was tried, and some farmers planted as much as 4 or 5 acres to this crop, but other crops better adapted to the climate were found to be more profitable, and the growing of cotton was discontinued. The commerce on the river and the Indian trade consumed the surplus products of the farm.

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CLIMATE.

A general idea of the climatic conditions of the area may be had by an examination of the appended table, compiled from Weather Bureau records, showing the normal monthly and annual temperature and precipitation at Mascoutah, situated in the eastern part of the area, and at St. Louis, on the western bank of the Mississippi River, directly opposite the northwestern corner of the area.

Normal monthly and annual temperature and precipitation.

Month.	Mascoutah.		St. Louis.	
	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	Inches.	° F.	Inches.
January	31.3	2.82	30.5	2.18
February	31.3	3.21	35.1	2.75
March	42.5	4.06	43.1	3.53
April	55.4	4.11	56.2	3.68
May	63.9	4.97	65.8	4.64
June	75.6	4.31	75.2	4.92
July	78.9	2.89	78.8	3.77
August	76.4	2.33	76.8	3.36
September	70.2	3.27	69.4	2.99
October	56.2	1.98	57.5	2.79
November	42.1	3.55	43.6	3.08
December	35.3	2.35	35.6	2.71
Year	55.0	39.85	55.6	40.40

As deduced from data given by the same records, the average dates of killing frost are as follows: Mascoutah, spring, April 23; fall, October 15. St. Louis, spring, April 2; fall, October 26. This gives an average growing season for tender vegetation of 175 and 207 days, respectively. There is thus quite a difference in the season in the eastern and western parts of the area, due doubtless to difference in elevation and the influence of the river.

PHYSIOGRAPHY AND GEOLOGY.

The surface of St. Clair County presents a pleasing variety of river bottoms, hills, and prairies. The largest area of bottom land is found along the Mississippi River, which forms the western boundary of the county for a considerable distance. This bottom is a part of what is known as the "Great American Bottoms." (See Pl. XXVIII.) At the northern boundary of St. Clair County it extends back as far as Caseyville, 8 miles from the river, but narrows down to 3 miles in width at the southern boundary. Nearly all of this bottom lies between 400 and 420 feet above sea level. At times of great floods in the Mississippi River it is overflowed, but the damage from this source has been decreased by the building of levees. The Kaskaskia River, which enters the county

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about midway of its eastern boundary and flows across it in a southwestern direction, forming the west-southern boundary, also has considerable bottom land along it. In its course through the area it swings from bluff to bluff, and on the side opposite the bluffs there are low, level strips of alluvial land sometimes as much as 2 miles in width. The bottoms along the Kaskaskia are generally timbered and contain many small lakes and bayous. Silver Creek, which enters from the north, and Richland Creek, which rises near O'Fallon, flow in a southern direction through the eastern and central portion of the county and empty into the Kaskaskia River. Both of these streams, as well as many other smaller ones, have narrow strips of bottom land along them. The Kaskaskia River is lower in St. Clair County than the Mississippi, and therefore receives the greater portion of the drainage.

The upland, which occupies the larger portion of the area, is more or less broken, depending somewhat upon the distance from the larger streams. The boundary between the upland and the bottoms is usually marked by a line of bluffs. This is especially true along the Mississippi River, where these bluffs rise to a height of from 100 to 250 feet above their base. Those along the Kaskaskia River are much less pronounced. The Mississippi bluffs are usually formed of loess, which overlies the glacial material, but beginning 3 miles south of Centerville Station and extending almost to Monroe County they are formed of an almost perpendicular wall of limestone 100 or more feet high. Above this limestone is about 6 feet of glacial material and from 50 to 100 feet of loess. In the rear of these limestone bluffs, in Sugar Loaf Township, are many sink holes.

The general character of the country along the bluffs is broken and hilly. The small streams, which are dry most of the year, have cut deep ravines, between which rise rounded ridges. These ridges are among the highest points in the county, sometimes reaching an elevation of 680 feet above sea level, and have been undoubtedly higher than at present, as it is evident that a great deal of soil has been removed by erosion. The divide between the Mississippi and the Kaskaskia rivers lies within a few miles of this bluff line. Back from the bluffs the surface becomes more level until in the central and eastern portion gently rolling prairies are found. Lebanon, Mascoutah, Shiloh Valley, and Prairie du Long townships are covered almost entirely by prairie, and many other smaller areas are found ramifying in a north and south direction between the streams.

A broken chain of glacial ridges, which probably represent a portion of an old moraine, enters the county north of Lebanon and extends southwestward to near Belleville. It there swings to the southward, following quite closely the course of Silver Creek. One of these

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ridges in Freeburg Township, known as Turkey Hill, is the highest point in the county.

The geological formations in St. Clair County comprise the Quaternary, the lower 350 feet of the Coal Measures, and about 300 feet of the Subcarboniferous limestone. The lowest formation which is exposed is the Subcarboniferous limestone, which outcrops in the bluffs around the southwest border of the coal field. Above this limestone lie the Coal Measures, consisting of interstratified beds of sandstones, shales, and limestones. The Coal Measures embrace five coal seams, but only two of these are of any economic importance and only one is worked. This seam averages about 6 feet thick, and the coal is of a good quality. The coal has been a source of great wealth to St. Clair County, which ranks as the second county in the State in the quantity of coal produced. These seams underly three-fourths of the county. The dip, which is toward the east, is moderate and amounts to about 5 or 6 feet to the mile. At the close of the Carboniferous period there was an upheaval that resulted in the area occupied by the western coal swamps becoming permanently dry land. Erosion began its work and the upper portion of the Coal Measures was removed and the surface made somewhat irregular.

The formations underlying the St. Clair County area rarely outcrop, for they are covered with a deposit of drift material brought down by the ice at the time of the Illinois glaciation. This drift material varies in thickness from a few feet to 125 feet, and as the underlying rocks had been eroded into valleys which were subsequently filled with the drift material it is thicker in some places than in others, even where the surface is level. At the base of the drift there is usually a bed of plastic blue clay, containing sometimes a few pebbles. In other localities stratified sands are found below the clay. The glacial material outcrops along many of the streams, especially in southern and southwestern parts of the county and also in many places along the bluffs. As seen here it consists largely of a reddish-yellow or bluish gravelly till with which there is often mixed a considerable percentage of a reddish-brown sand. Very few bowlders were noticed. Many fragments of quartz as well as of granite and other igneous rocks occur, but a large part of the drift consists of the material ground off the sandstones, shales, and limestones of the Coal Measures by the ice as it moved over them. The drift material usually shows an imperfect stratification.

Overlying the gravelly till of the Illinois glaciation is a deposit of very fine sand, silt, and clay, of a yellowish or chocolate color, so slightly coherent that it can be readily pulverized between the thumb and fingers, and yet possessing sufficient tenacity to enable it to stand up in perpendicular walls where cut by stream erosion. This deposit contains shells, concretions of calcium carbonate, and pipes of iron,

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and forms a part of the loess of the Mississippi Valley. This loess occurs as a natural levee along the bluffs, where it sometimes attains a thickness of 100 feet, but thins out rapidly toward the east. Except near the bluffs no typical sections of unweathered loess were seen, but the similarity of the material farther east to the weathered product leads to the belief that a thin layer of the loess extended over almost all of the upland. The particles composing the loess usually become coarser toward the bottom, and the material sometimes grades into a yellowish fine sand which shows evidence of stratification.

SOILS.

The different types of soil recognized in this area fall naturally into two main physiographic divisions, the alluvial bottom lands and the uplands. The names and areas of the different types are given below:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami fine sandy loam	138,560	33.3	Kaskaskia loam	9,664	2.3
Miami silt loam	106,432	25.6	Lintonia loam	5,696	1.4
Marion silt loam	86,464	20.8	Yazoo loam	4,160	1.0
Yazoo clay	26,944	6.5	Total	415,872	....
Waverly silt loam	25,152	6.0			
Yazoo sandy loam	12,800	3.1			

MIAMI FINE SANDY LOAM.

The Miami fine sandy loam consists of a loose, fine, and very fine sandy loam with which there is mixed a large percentage of silt. The soil has an average depth of 15 inches. When dry the color is a gray or pale yellow, but when moistened by rains it becomes a light brown. On the hills or bluffs, where erosion has been very active, the soil has been partially or entirely removed, and the heavier reddish-yellow subsoil is found near or at the surface. The soil gradually becomes finer in texture as one recedes from the bluff, the size of the grains and the amount of sand decreasing and the percentage of silt increasing until, near the eastern boundary of the area, the type becomes quite silty.

The subsoil is a yellow to reddish-yellow heavy silt loam, often quite hard but friable. This material extends to a depth of from 3 to 20 feet. Along the bluffs and back upon the uplands for several miles it is underlain by the unweathered chocolate or yellow-colored loess, which is sometimes as much as 100 feet in thickness near the bluffs, but which thins out rapidly toward the interior until it becomes so thin that the processes of weathering have extended downward entirely through it. Erosion has been much more active along the bluffs and

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has removed the weathered material almost as fast as it has formed. The loess is underlain by the gravelly till of the Illinois glaciation. This glacial material outcrops in the deep ravines and along the foot of the bluff.

The following analyses show the texture of the Miami fine sandy loam, from which it is seen that the fine sandy character in the field is more apparent than real.

Mechanical analyses of Miami fine sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7027	2 miles NE. of O'Fallon.	Yellow to gray fine sandy loam, 0 to 16 inches.	0.61	0.06	0.34	0.36	0.78	2.80	87.46	7.88
7021	5 miles NW. of Belleville.	Gray fine sandy loam, 0 to 14 inches.	1.62	.52	1.00	.34	.46	3.34	85.30	8.92
7023	10½ miles W. of Belleville.	Pale yellow fine sandy loam, 0 to 14 inches.	1.37	.02	.36	.24	.58	3.60	85.64	9.56
7028	Subsoil of 7027......	Yellow silty loam, 16 to 40 inches.	1.03	.02	.40	.44	.66	2.58	78.68	16.64
7022	Subsoil of 7021.....	Heavy yellow silty loam, 14 to 36 inches.	.42	.32	.90	.42	.68	2.96	77.04	17.32
7024	Subsoil of 7023......	Yellow silty loam, 14 to 36 inches.	.46	.00	.24	.18	.32	1.82	76.00	21.08

The Miami fine sandy loam is found all along the bluffs, from which it extends back into the uplands for a distance of from 5 to 15 miles. It occupies the greater part of the area between Silver Creek and the Mississippi River bottom north of an irregular line drawn through Freeburg, Smithton, and Millstadt. It occurs in a broad extended area, broken somewhat by smaller areas of Miami silt loam. The surface is rolling to hilly. The bluffs rise rather abruptly to a height of from 100 to 250 feet, and are cut by deep gullies or ravines, between which are rounded, dome-shaped knobs and ridges. Farther back upon the uplands the surface becomes more level. Near the eastern border of the area the surface is more hilly, owing to the presence of the glacial ridges. In Sugar Loaf Township the surface is very irregular, on account of the large number of sink holes. These holes are from 50 to 200 yards in diameter and sometimes 50 feet deep. Many of them contain water. They are quite an impediment to the cultivation of the soil. The character of the surface and the underlying material give the Miami fine sandy loam good drainage.

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The Miami fine sandy loam has been derived directly from the weathering of the loess. The loess is composed of sharp, angular, unweathered particles very uniform in size. It contains shells, concretions of calcium carbonate, and pipes of iron. There has been a great deal written about the origin of the loess and it is not the intention to go into a discussion of the subject in this place. As found here it is generally believed to represent the fine material ground up by the ice during the Glacial epoch, "borne southward by the streams and deposited in water just sufficiently in motion to carry the fine clay farther away."[a] Afterwards it became dry and was drifted about by the wind. It was certainly deposited after the Illinois glaciation, as it is found directly overlying the glacial material. As the unweathered particles of the loess are attacked by the processes of weathering they gradually give up their stores of plant food, thus serving as the source of a constant supply of most of the elements required for plant growth. The loess is generally rich in lime, magnesium, iron, aluminum, and potash.

Wheat, corn, oats, hay, Irish potatoes, orchard fruits, and market-garden crops are all grown upon the Miami fine sandy loam, but probably as much as one-half of the area is sown to wheat. This grain averages about 15 bushels per acre, although much larger yields are obtained in good seasons. Corn yields about 35 bushels, oats about the same, hay from 1 to 1½ tons, and Irish potatoes 75 bushels per acre. Much larger crops are obtained by the best farmers. Apples, pears, plums, peaches, cherries, and grapes do well on this soil and yield profitable returns. There is an excellent opportunity for development of the fruit industry, especially along the bluffs and in the other hilly areas. The soil is also adapted to the growing of strawberries, tomatoes, cabbage, and other market-garden crops, the cultivation of which could undoubtedly be made more profitable than the growing of grain.

MIAMI SILT LOAM.

The Miami silt loam is distinctly a silty soil. It is uniform in texture and contains a considerable percentage of organic matter, that gives to it a dark-brown color when moist. When dry and when it has not been stirred for several weeks the color becomes somewhat ashy. The soil adheres slightly when moist, but does not bake and is easily tilled. It is distinguished from the other upland soils by its darker color and heavier character. This soil type, where contiguous to the Marion silt loam, grades toward the latter. Occasional outcrops of "hardpan" are then seen, and some iron and calcium concretions are found. The soil is deepest in the depressions, sometimes extending to a depth of 36 inches, although the average depth is about 18

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[a] Rocks, Rock-weathering, and Soils. Merrill.

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inches. The subsoil, into which the soil passes by degrees, is a yellow or mottled-yellow silty clay loam, in which the silt is a very prominent component. When dry the subsoil becomes quite hard, though crumbling easily to the touch. When wet it is plastic. The character of the subsoil of the Miami silt loam is entirely different from the subsoil of the Marion silt loam. At a depth of 4 or 5 feet the silty clay loam material grades into the loesslike material that overlies the glacial till and is similar to the subsoil of the Miami fine sandy loam.

Below are given the mechanical analyses of samples of Miami silt loam:

Mechanical analyses of Miami silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7029	7 miles N. and 1 E. of Belleville.	Brown silty loam, 0 to 15 inches.	2.86	0.32	0.56	0.18	0.28	3.34	86.24	9.08
7033	4 miles NE. of Mascoutah.	Brown silty loam, 0 to 16 inches.	3.22	.06	.40	.28	.42	3.78	84.62	10.44
7031	3 miles W. of Marissa	Brown silty loam, 0 to 14 inches.	2.41	.74	1.48	.46	.80	4.08	70.50	20.96
7030	Subsoil of 7029......	Mottled-yellow silty clay loam, 18 to 36 inches.	.33	.70	1.00	.44	2.64	8.40	76.86	9.04
7034	Subsoil of 7033......	Stiff silty clay, 16 to 36 inches.	1.13	.24	.64	.34	.60	2.56	80.82	14.80
7032	Subsoil of 7031......	Mottled silty clay, 14 to 36 inches.	1.30	.54	1.36	.54	1.42	2.76	57.88	35.30

The Miami silt loam occupies almost the entire northeastern part of the county, where it is found in a broad, extended area covering nearly all of Lebanon, Mascoutah, and Shiloh Valley townships and reaching south to Fayetteville. Another area of considerable extent, known as Ridge Prairie, is found near O'Fallon. Other smaller areas occur southwest of Belleville, south of Freeburg, and west of Marissa. There are some outcrops of "hardpan" in the two areas last named, and their average yield of crops is not as high as that of the areas farther north, where the hardpan is many feet below the surface.

The surface of the Miami silt loam is that of a level to gently rolling prairie. It is more rolling near the streams, because of the greater amount of erosion that has taken place there. It occupies slight depressions, probably the basins of old shallow lakes that have been gradually drained by erosion and changed into wet, grassy prairie. When the first settlers came to this country they found a large part of the area occupied by the Miami silt loam in this prairie condition. These areas were drained by cutting large open ditches through them,

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and later by the very limited use of tile drains. Some of the areas in the southern part of the county are still too wet to produce good crops and should be drained.

The Miami silt loam has been formed by the weathering of the loess-like material which underlies it and the incorporation in the soil, while the areas were wet and swampy, of the organic matter resulting from the decay of the rank vegetation peculiar to moist situations. Silt also was washed in from the higher areas.

The Miami silt loam is the best type of upland soil in the county for general farming purposes. Wheat forms the principal crop, and this soil is generally considered one of the best types of soil in the State for growing this crop. Yields of 40 bushels per acre are reported, but such yields are very rare, and from 15 to 18 bushels will more nearly represent the average yield. Corn is the second crop in importance and will produce an average of 40 bushels per acre, although some farmers gather twice that quantity in good seasons. The yield of oats is about the same as that of corn. Clover and grass produce from 1 to 2 tons of hay per acre. Alfalfa is being tried upon the State experiment field near Mascoutah and promises good results. Irish potatoes are grown in considerable quantities, the yield being about 75 bushels per acre. This soil is easily cultivated, retains moisture very well, and is quite productive. It has been devoted too constantly to the production of wheat, and a more systematic rotation of crops should be practiced.

MARION SILT LOAM.

The Marion silt loam, to a depth of 10 inches, is composed of a gray to whitish or ash-colored silty loam, containing from 5 to 10 per cent of iron concretions about the size of small shot. The soil becomes somewhat hard after rains, but when stirred and pulverized it becomes loose. When dry it forms an impalpable dust, in texture about like flour. The "post-oak" lands are especially loose and silty and resemble ground-up chalk. Between the soil and the true subsoil is usually a layer, about 5 inches thick, of a white, powdery, siliceous silt and very fine sand, containing concretions of hydrated iron oxide. This layer seems very compact in the borings, but crumbles and pulverizes very readily between the thumb and finger. It is sometimes absent, and this most often happens upon the more rolling areas along the streams. At a depth of 15 inches the true subsoil is reached. This is a distinctive feature of the Marion silt loam and exercises a leading influence upon the agricultural value of the type. It consists of a hard, intractable, impervious, very silty clay of a mottled brownish-yellow color, and contains many iron concretions. In some instances concretions of calcium carbonate were also noticed. This subsoil is locally known as "hardpan." Where the soil is shallow and the subsoil reaches the surface there are found the so-called "scalds" or bar-

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ren spots. It is very difficult to plow these spots, and after a heavy rain the ground runs together and becomes as hard as before. The subsoil holds water like an earthen vessel. One of the most common methods of obtaining water for stock is to excavate a hole 3 or 4 feet deep and allow the rain water to accumulate therein. An instance was noticed where one of these ponds was within 10 feet of a well 20 feet deep, yet so impervious is the subsoil that water in the pond remains until carried off by evaporation.

There is usually a gradation from the Marion silt loam to the Miami fine sandy loam or the Miami silt loam, and no sharp boundary exists between them, although where typically developed the three types are very distinct.

The mechanical analyses of samples of Marion silt loam are given below:

Mechanical analyses of Marion silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7008	3 miles W. of New Athens.	Light-gray silty loam, 0 to 12 inches.	2.04	0.10	1.04	0.66	0.74	2.96	82.94	11.48
7004	2 miles E. of Lenzburg.	Gray silty loam, 0 to 16 inches.	1.45	.44	.80	.50	.56	7.40	78.66	11.56
7006	1¼ miles W. of Darmstadt.	Gray silty loam, 0 to 14 inches.	1.08	.90	1.54	.58	.66	2.60	77.84	16.08
7009	Subsoil of 7008......	Silt and sand, 12 to 20 inches.	.90	1.10	1.76	.98	1.06	3.50	79.76	11.84
7005	Subsoil of 7004......	Silty clay, 16 to 36 inches.	1.19	.40	1.04	.70	1.00	4.32	63.82	28.28
7007	Subsoil of 7006......	Yellow clayey silt, 14 to 36 inches.	.48	.16	.78	.48	.96	2.18	57.20	37.50
7010	Subsoil of 7008......	Mottled silty clay, 20 to 36 inches.	.99	.14	.66	.58	.80	1.58	58.04	38.06

The greater part of the southern one-third of the county is covered by the Marion silt loam. Beginning near Millstadt, the area extends in a southeastern direction and takes in the larger part of Prairie du Long Township. Areas also occur south and east of New Athens, and Fayetteville and Marissa townships are composed largely of this soil type.

The Marion silt loam is most typically developed upon the level to gently rolling prairies in Clinton County and other counties lying east of St. Clair. (See Pl. XXVII.) The surface in St. Clair County is more diversified. In Prairie du Long Township and around Darmstadt level to gently rolling prairies are found, but the surface in the other areas is more broken and hilly, due to the greater amount of erosion. These areas, owing to the rolling and hilly character of the sur-

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face, possess good natural drainage, but the more level prairies would be improved by drainage. Some difficulty is experienced, however, from the impervious character of the subsoil, but open ditches to carry off the water which covers the surface after heavy rains would undoubtedly be beneficial.

The Marion silt loam represents the weathered product of a thin layer of loesslike material which overlies the gravelly till of the Illinois glaciation. In some instances the soil seems to be derived directly from the glacial material itself. It is very probable the loesslike material from which this soil is derived once covered the whole area and the country to the east. In exposed places it has been removed by erosion, and the glacial material comes to the surface. The Marion silt loam seems to be closely connected also with the glacial material, for wherever the latter is exposed there are found evidences of the so-called hardpan, which forms the subsoil of the type. The Marion silt loam is found much nearer the bluff near Millstadt than anywhere else in the area, and here the glacial material, on account of an anticline in the underlying limestones, is much nearer the surface than at other places along the bluff.

The Marion silt loam is recognized as a poor type of soil for general farming. Wheat does better than any other grain. The average yield for this year (1902), which has been an exceptionally good year, was between 20 and 25 bushels per acre, but the average for a period of ten years is probably not more than 12 bushels per acre. Seventy-five per cent of this type is seeded to wheat each year. The reason why wheat produces better than other grain crops is probably because there is more moisture in the soil in the spring and early summer than later in the season. In addition to other factors, plants require a proper supply of moisture and also room for the development of their roots. The hard and impervious subsoil acts as a very poor storehouse for moisture and also hinders the root growth. Corn requires moisture at the time of the year when evaporation is greatest, and unless the soil absorbs and holds the moisture which falls as rain, so that the corn can have a supply to draw upon during periods of dry weather, the crop will be cut short. This soil is therefore very poorly adapted to corn, and the yields obtained are very light. Hay is grown and yields about 1 ton per acre. Fruits—such as apples, pears, peaches, and strawberries—thrive, and if cared for properly would give much more profitable returns than grain. The fruits do best where the surface is rolling and the subsoil more easily penetrated by the roots. More attention should be given to the growing of fruits.

The Marion silt loam in St. Clair County will average better than the same soil in Clinton County. The subsoil contains less iron and is not quite so hard, especially in the areas southwest of Freeburg and around Darmstadt. Its light, almost white color indicates that it is in need of organic matter, which should be supplied by the use of stable

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manure and the plowing under of cowpeas, clover, and other leguminous crops.

YAZOO CLAY.

The soil of the Yazoo clay to a depth of 6 inches consists of a dark-brown to drab-colored clay loam, with which there has been mixed a large percentage of silt. When wet it becomes almost black, its dark color being due to the large amount of organic matter which it contains. When dry it cracks open, but these cracks usually do not extend to a depth of more than 4 inches, although instances were noticed where they reached to a much greater depth and were of sufficient width to admit one's hand. The soil possesses the property of granulation to a very remarkable degree. As soon as the soil begins to dry after a rain it begins to check into cubes. This process of granulation continues until the entire surface is covered with an inch or more of loose material. This property of granulation has given to the soil the local name of "buckshot" land. It is also spoken of as "gumbo," on account of its sticky nature when wet. It is so adhesive that 3 or 4 inches of the surrounding soil will stick to the auger when it is withdrawn from a boring.

The subsoil to a depth of 40 inches consists of a tough, plastic, sticky, drab-colored clay containing much silt, but retaining the properties of a clay. The depth of this clay varies in different parts of the area. Some wells have been dug to a depth of 20 feet before reaching the underlying sand, but the average depth of the clay subsoil is probably not over 4 or 5 feet, and sometimes, near the boundary between this type and the Yazoo sandy loam, the clay does not extend below 3 feet from the surface.

The following analyses show the heavy character of the Yazoo clay:

Mechanical analyses of Yazoo clay.

No	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7041	1¼ miles S. of Prairie du Pont.	Brown silty clay loam, 0 to 6 inches.	4.28	0.14	0.83	0.62	1.77	12.98	48.83	34.88
7043	1¾ miles W. of Caseyville.	Brown silty clay loam, 0 to 7 inches.	4.01	.18	1.28	.78	1.96	5.78	51.20	38.88
7045	1¼ miles SE. of East Carondelet.	Brown silty clay loam, 0 to 5 inches.	2.97	.00	.66	.72	3.40	7.68	42.82	44.80
7044	Subsoil of 7043	Heavy silty clay, 7 to 36 inches.	.92	.10	.36	.36	1.58	5.38	49.54	41.82
7046	Subsoil of 7045	Drab silty clay, 5 to 36 inches.	1.06	.00	.30	.40	1.92	3.40	49.12	44.50
7042	Subsoil of 7041	Drab silty clay, 6 to 40 inches.	1.78	.00	.44	.34	1.84	6.44	39.78	50.16

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A large part of the American Bottoms in St. Clair County is covered by a deposit of the Yazoo clay. This type of soil was first recognized in the Yazoo River delta in Mississippi, and as it has also been found along the Illinois River in Tazewell County, it is probable that it covers a large percentage of the bottom lands along the Mississippi River and its tributaries. A large area of this soil is found in and around East St. Louis, where it is fast being taken up for building purposes. It occupies nearly all of the bottom between East St. Louis and the bluffs. Another large area is found in the southern part of the bottom, and a few smaller areas occur along the Kaskaskia River.

The generally level character of the surface of the Yazoo clay is somewhat broken by low ridges and by depressions. The latter represent old lake beds or bayous left after the overflow of the river. Some of these lakes are still undrained and contain water during a large part of the year. One of the largest lies in the northern part of the area. Another one is situated south of Centerville Station. The greater part of the area of this soil could be improved by underdrainage, and there are large tracts that are entirely too wet and swampy for cultivation. The elevation above the river is so little that it would probably be necessary to use the pump in draining some areas. The great and lasting fertility of the soil, coupled with the nearness of the St. Louis market, would probably make its reclamation profitable.

The origin of the alluvial bottom lands in general, as a deposit from the flood waters of the river, has already been indicated. The Yazoo clay represents the accumulation of the finest particles held in suspension by the water and deposited where there was little current. The precipitation of material as fine as that which makes up the body of the Yazoo clay would be prevented by even a moderate motion. Even in quiet water, such as would be found in depressions after the subsidence of the flood, the precipitation of the sediment could well consume a period of weeks. The position of the soil in the depressions and low areas generally attests its formation by deposition under the conditions described.

The American Bottoms are widely known for their fertility, and this fame is largely due to the productiveness of the Yazoo clay. It is an exceedingly fertile soil and has produced crops for many years without any diminution of its productiveness. Wheat, corn, oats, and hay are the principal crops grown, and where properly drained excellent crops are obtained, although the average yield is not very high because of the poor drainage. Wheat produces about 15 bushels, corn 50 bushels, oats 35 bushels, and hay 1 to 1½ tons to the acre. Some difficulty is experienced in getting a good stand of wheat on account of a tendency of the plants to winterkill. The damage from this source could no doubt be lessened by underdraining. Irish potatoes and tomatoes are grown, but these and similar crops do better on the

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lighter soils. This type was originally heavily timbered with some small prairies scattered through the timber, but it is now largely cleared. The uncleared areas are used as pastures.

WAVERLY SILT LOAM.

The soil of the Waverly silt loam is a whitish to brown silty loam. Along the streams which issue from areas of Miami fine sandy loam there is a decrease in the amount of silt present and a corresponding increase in the percentage of fine and very fine sand. This silty loam material extends to an average depth of 14 inches, although instances were noticed where there was very little change to a depth of 36 inches. The subsoil consists of a gray or mottled yellow clay containing a very large proportion of silt. Both soil and subsoil show brown iron stains and often a small percentage of iron concretions.

The following are analyses of samples of Waverly silt loam:

Mechanical analyses of Waverly silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7019	1¼ miles N. of New Athens.	Mottled gray silty loam, 0 to 20 inches.	1.10	0.34	1.00	0.84	3.56	15.72	61.60	17.02
7017	1 mile W. of Mascoutah.	Brown silty loam, 0 to 12 inches.	2.16	.24	.24	.24	1.78	7.12	72.32	18.10
7020	Subsoil of 7019......	Heavy silty loam, 20 to 40 inches.	.20	.76	1.38	1.14	5.10	7.52	68.62	15.20
7018	Subsoil of 7017......	Drab silty loam, 12 to 36 inches.	1.18	.16	.52	1.46	11.00	7.24	61.44	18.60

The Waverly silt loam is not a very extensive or important type. It is found along the smaller streams and in high-lying areas near the foot of the bluffs along the Kaskaskia River. The surface is generally level, and it is subject to occasional overflows. Much of it is low and wet and in need of artificial drainage. Some of the areas along the smaller streams are, however, elevated enough to insure good drainage. The greater part of the areas require diking to protect them from overflow.

This type of soil has been washed from the hills by the rains and deposited over the level lands at the foot of the hills, or has been transported by the streams to a greater distance and spread out over their bottoms by overflowing waters.

Like the Kaskaskia loam, the greater part of this type of soil is still covered by its original growth of timber. More of it has been cleared

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and brought under cultivation along the smaller than along the larger streams. This is due to the better drainage conditions which exist there and to the less damage from floods. These streams, coming only a short distance and having more fall, do not, when they overflow, remain over the land as long as the larger streams and therefore do much less damage. Corn and grass are the two principal crops grown on this type of soil. Yields of from 40 to 50 bushels of corn and of 2 tons of hay to the acre are obtained in favorable seasons. The Waverly silt loam is not as good a soil as the Kaskaskia loam. It contains less organic matter and does not retain moisture as well.

YAZOO SANDY LOAM.

The soil of the Yazoo sandy loam consists of a pale-yellow or brown sandy loam or loamy sand with an average depth of 12 inches. The size of the grains of sand varies somewhat in different places, from the medium to the very fine grades. Near areas of Yazoo clay the soil becomes more loamy in character, a condition due to the larger amount of finer material which it carries. It is also more loamy in the hollows between the sandy ridges, and in general it is more sandy near the Mississippi River. The brown phase is heavier and contains more organic matter. The subsoil is heavier than the soil and consists of a pale-yellowish, fine, very sandy loam or, as near the Yazoo clay, sometimes of a silty clay. There is no sharp line of demarcation between the soil and subsoil, but rather an almost imperceptible grading of one into the other.

Below are given the mechanical analyses of samples of Yazoo sandy loam:

Mechanical analyses of Yazoo sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7085	1 mile W. of Prairie du Pont.	Fine sand, 0 to 14 inches.	0.55	0.00	0.04	0.06	40.48	47.78	9.32	2.32
7087	1¼ miles SW. of Caseyville.	Sandy loam, 0 to 7 inches.	1.94	.54	1.36	1.14	2.68	16.84	71.80	4.94
7089	¼ mile S. of Church.	Brown sandy loam, 0 to 18 inches.	1.89	Tr.	.44	.20	16.48	42.38	27.36	12.82
7086	Subsoil of 7085......	Pale yellow fine loamy sand, 14 to 36 inches.	1.24	.02	.08	.14	7.06	45.00	43.44	3.74
7088	Subsoil of 7087......	Sandy and silty loam, 7 to 36 inches.	1.81	.14	.80	.42	1.98	15.88	74.64	5.22
7040	Subsoil of 7089......	Yellow sandy loam, 18 to 36 inches.	.91	.00	Tr.	.14	6.96	38.84	44.58	9.92

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The largest area of this type of soil is found along the front lands of the Mississippi River, beginning just south of East St. Louis and extending along the river to the Monroe County line. Other smaller areas are found scattered over different portions of the American bottoms. It also occurs in small areas along the Kaskaskia River, the largest of these areas being east and south of Fayetteville. It occupies the higher, better-drained parts of the bottom land. The surface is slightly rolling and is made up of a series of low, sandy ridges between which occur slight depressions. There is probably not more than 10 or 15 feet difference in its elevation in any portion of the Mississippi bottom. Owing to its position in the higher areas and its sandy texture this soil usually possesses good drainage. The entire bottom lands are sometimes overflowed during the great floods in the Mississippi River, but the greater portion of the areas occupied by this soil type are seldom covered with water. Levees have been built in many places, and the danger from overflow has been decreased.

The origin of the Yazoo sandy loam is found in the great floods of the Mississippi River. One of the greatest upon record occurred in 1844, when the river spread from bluff to bluff and was of sufficient depth to allow the passage of steamboats near the bluffs. It is said that deposits 10 feet in thickness were left by this single flood. The effect of water transportation is to sort the suspended particles, the heavier being deposited first upon slacking of the current. The Yazoo sandy loam represents this heavier deposition. The sand is composed largely of quartz.

Almost all crops produced in this section can be grown upon the Yazoo sandy loam. It is too light and sandy, however, for general agricultural purposes. The heavier phase will produce fair crops of corn, but it should not be used for any except the early varieties. It is well adapted to the growing of truck and market-garden crops, and considerable areas, especially near East St. Louis, are being used for this purpose. There is yet room for a greater development of this industry. Watermelons, muskmelons, strawberries, cabbages, tomatoes, and many other similar crops could be grown with much profit. The soil is situated near one of the great markets of the country, and a ready sale would be assured for a much greater quantity of this class of products. A more intensive system of cultivation and the exclusive use of these soils for truck and market-garden crops would cause an increase in their value.

KASKASKIA LOAM.

The soil of the Kaskaskia loam consists of a brown loam containing much silt and having a depth of 9 inches. Its structure varies from compact to granular. In most instances where this soil had been cultivated this slightly granular structure was noticed. It is a rather heavy loam, the heaviness being due to the large percentage of silt which it contains. Thoroughly mixed with this soil also is a large

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percentage of the decayed organic remains resulting from the heavy forest growth which is found upon it. As is often the case in alluvial soils, there is no sharp line of demarcation between the soil and the subsoil, the latter gradually becoming heavier with depth on account of the increase in the proportion of silt and clay contained. The subsoil is a mottled gray and yellow silty loam, often quite heavy in the low places, but frequently becoming somewhat sandy in the lower depths.

The mechanical analyses of Kaskaskia loam are given below, from which it is seen to contain much more clay than the field examination would indicate.

Mechanical analyses of Kaskaskia loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7013	1 mile W. of New Athens.	Brown loam, 0 to 9 inches.	2.75	0.02	0.54	0.68	2.92	2.66	57.44	35.66
7015	6 miles SE. of Mascoutah.	Brown loam, 0 to 12 inches.	3.49	.06	.14	.36	8.80	4.74	42.98	42.84
7016	Subsoil of 7015......	Mottled drab silty loam, 14 to 36 inches.	1.19	Tr.	.44	.72	18.02	9.14	42.08	28.86
7014	Subsoil of 7013......	Drab silty clay, 9 to 36 inches.	1.33	.16	1.36	.86	1.60	1.54	50.52	43.94

This soil is found in the low alluvial bottoms along the Kaskaskia River within the area. The Kaskaskia bottoms are not very wide, and therefore this type of soil does not occur in as large areas as are found in Clinton County. At Fayetteville, and extending north for 2½ miles, the bluffs come very close to the river and in times of flood back the waters over the bottoms for miles up the stream. From Fayetteville south the soil occurs as a strip with an average width of about one-half mile, narrowing down in some places and then widening out again.

The surface of this soil is in general level, but is somewhat broken by the many bayous and lakes which have been formed during the overflow of the river. They represent old stream channels which have been left in the swinging of the stream when, during some time of very high water, the river has made for itself a new channel. The entire area occupied by the Kaskaskia loam is subject to overflow, and in many places the water has remained a sufficient length of time to leave a watermark from 4 to 6 feet from the ground. The river, however, does not overflow every season, and in these years it would be possible to grow fine crops. The greater portion of the area would require drainage, which could be accomplished in many instances by

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draining into the old lakes or bayous. In order to insure the crops against damage or destruction from overflow it would be necessary to construct levees.

The fall in the Kaskaskia River within the area is not as great as that of the Mississippi at St. Louis, and the current is not as swift. When after heavy rainfalls the river, carrying in suspension its heavy load of material washed from the country to the north, rises and overflows its banks, its current is checked, and a part of its load is deposited. Mixed with this deposited material is the organic matter resulting from the decay of the leaves and dead limbs which drop from the heavy forests, together with that which accumulates from the decay of the undergrowth. This process of alternating deposition of mineral and organic matter, continued for years and still continuing, has produced the Kaskaskia loam.

Nearly all of the Kaskaskia loam is still covered with a heavy forest of oak, elm, maple, hickory, birch, sycamore, and many other trees. A few small areas more elevated than the general body of the soil have been cleared and cultivated and produce excellent crops of corn and hay, but there is always danger that the crops may be destroyed by an overflow of the river. The Kaskaskia loam is a very fertile soil and if it were protected from the floods and properly drained it would produce very fine crops of corn and hay.

LINTONIA LOAM.

The Lintonia loam consists of a brown loam with which there is mixed a considerable percentage of fine and very fine sand and silt. The soil, however, retains the characteristics of a loam rather than a sandy loam. It is quite uniform in texture to a depth of 20 inches, and often there is little change to a depth of 3 feet. The subsoil varies considerably. The reason for this will be evident when we consider the method of its formation. Nearest the bluff it usually consists of a reddish-brown or yellow silty loam, but where it lies adjacent to the Yazoo clay the subsoil becomes much heavier. The following analyses show the texture of the Lintonia loam:

Mechanical analyses of Lintonia loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7011	½ mile SW. of Caseyville.	Brown silty loam, 0 to 18 inches.	1.97	0.06	0.30	0.18	0.60	11.16	82.28	5.36
7012	Subsoil of 7011	Brownish-yellow silty loam, 18 to 36 inches.	1.90	.00	.22	.20	.36	10.38	81.32	7.52

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The Lintonia loam occupies only a small percentage of the area. It occurs as a narrow band along the foot of the Mississippi River bluffs and extends up the small streams which flow out from them. It is broadest where these streams issue from the bluffs and have spread it out in fan-shaped deltas over the adjoining bottom lands. It rises gradually from the level of the bottoms as a gentle slope and is therefore usually well drained. Where it occurs along the streams it is subject to occasional overflow.

The position of the Lintonia loam suggests at once the method of its formation. It represents material which has been washed down from the bluffs during periods of rainfall. The water coming down from the hills is enabled by means of its high velocity to carry heavy loads of material, but when the more level land is reached the velocity is checked and the material carried in suspension is deposited. Each succeeding rainfall brings down its load of material, depositing it a little farther out than the last one. The area of the Lintonia loam is therefore being gradually extended. The material thus deposited is derived almost entirely from the loess formation, and therefore it is a fertile soil.

The Lintonia loam is easily cultivated and produces good yields of almost all the crops grown in the area. Corn, wheat, oats, hay, Irish potatoes, truck, and market-garden crops are all found in different parts of the area. When seen the corn was doing well and gave promise of a yield of 50 or more bushels to the acre. Some sweet corn was noticed, and the growing of more of this would no doubt prove profitable. The type is well adapted to the growing of Irish potatoes and yields of 200 bushels an acre are not uncommon. It should be used for the growing of Irish potatoes, green corn, pease, tomatoes, cabbage, and other truck and market-garden crops, for which there is a good market.

YAZOO LOAM.

The soil of the Yazoo loam is composed of a slightly sandy brown loam, having a depth of 14 inches. It is a heavier loam than the Lintonia loam, due to the larger amount of clay which it contains. It is fairly uniform, but contains more sand in some places than in others. It is an intermediate type between the Yazoo clay and the Yazoo sandy loam. The subsoil varies much more in texture than the soil. It often consists of two or more strata. The lower one, beginning at a depth of about 30 inches, is a fine loamy sand, similar to the surface soil of the Yazoo sandy loam. Between this and the soil is found a stratum of a yellowish silty and fine sandy loam. In a few instances, however, this middle layer was lacking and the soil rested directly upon the sand.

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The mechanical analyses of Yazoo loam are given below:

Mechanical analyses of Yazoo loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7001	¼ mile S. of Prairie du Pont.	Brown sandy loam, 0 to 14 inches.	3.94	0.06	0.18	0.12	1.84	23.10	58.70	16.08
7003	¼ mile SE. of Cahokia.	Brown loam, 0 to 16 inches.	2.49	.00	.20	.36	30.14	13.16	35.52	20.42
7002	Subsoil of 7001......	Loam with fine sand and silt, 14 to 36 inches.	1.76	.00	.56	.24	1.40	30.38	50.78	16.18

The largest areas of Yazoo loam are found south and southeast of Cahokia. Other smaller areas occur in the northeastern part of the American Bottoms. It generally occupies the higher lying areas or low, broad ridges. The surface is slightly rolling. As this soil is situated upon the higher lying lands, it is usually well drained. The underlying layer of sand also assists in giving to it a good underdrainage. It is not subject to overflow, except during the very highest floods, and there is very little danger from this source.

The Yazoo loam is an alluvial deposit, having been formed by the overflow of the Mississippi River during periods of very high water. The different layers were probably formed during different times of overflow. Wherever the swift current was checked suddenly, there it deposited its load of sand, the finer material settling in stiller water.

Corn and wheat form the principal crops grown on the Yazoo loam, and average yields of from 35 to 40 bushels of corn and from 15 to 18 bushels of wheat to the acre are obtained. The present season (1902) the average yield of wheat was considerably more than that given above. Irish potatoes, sweet corn, tomatoes, cabbage, and other similar crops are grown to a limited extent only. On account of the adaptability of the soil to these crops and the excellent market facilities, greater attention should be given to them.

AGRICULTURAL METHODS.

While a large number of the farms in St. Clair County are cultivated in accordance with the latest and most progressive ideas, still an improvement in the methods used could be made in many cases with profit to the owner. The practice of removing each year a large amount of plant food from the soil without any compensation in the use of manures always leads sooner or later to a deterioration in the

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productiveness of the soil, although it may not be evident for a number of years. The methods followed for many years by a majority of the farmers of the area tended to bring about this result. Crop after crop was harvested and the fertility which these represented was hauled off the farm without any effort being made to replace it. The straw was burned to get it out of the way, and even the small amount of manure which was made was either burned with the straw or put in some gully to prevent washing. Such methods, however, have been abandoned by the more intelligent and progressive farmers, although many instances of thoughtless waste were noticed in all parts of the county. Commercial fertilizers are beginning to be used by some of the farmers. There is no doubt that they increase the yield and in some cases their use is to be recommended, but the fact that they enter a considerable item upon the expense side of the account should not be overlooked. The purchase of commercial fertilizers while at the same time the manure made upon the farm is allowed to go to waste is certainly not wise. Stable manure not only furnishes valuable plant food, but also improves the texture of the soil and assists in its capacity for the retention of moisture. Not only should more stock be raised and more manure be applied to the soil, but also the practice, which is followed by many farmers, of plowing under green crops, especially leguminous crops, such as cowpeas and clover, should be more generally followed. These plants furnish good forage for stock and at the same time improve the soil.

Experiments have shown that there are very few soils, however rich they may be, that will continue to produce the same crop every year without any diminution in the yields, and a rotation of crops therefore becomes necessary. The majority of farmers of St. Clair County have no regular system of rotation, while many of the fields are seeded to wheat continuously year after year, without giving the soil any change or rest. The rotation which seems to be most commonly practiced is to follow one year of clover with one or two years of corn, and then with four or five years of wheat. Oats are sometimes introduced into the rotation. A more systematic rotation and greater diversity in the crops has been introduced within the last few years, especially upon the Miami silt loam and Miami fine sandy loam.

In some years the rainfall during the summer season is not in sufficient quantity, or is too irregularly distributed, to produce a good crop of corn, and the question of conserving the moisture in the soil becomes a very important one. The corn should be cultivated as soon as possible after each heavy rain, so as to form a soil mulch to decrease the loss of moisture by evaporation. The usual method of "laying by" is to throw the soil up against the corn with a turning plow, thus not only cutting off the roots to a depth of 3 or 4 inches, but also exposing a larger soil surface to evaporation. An actual measurement

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VIEW OF THE UPLANDS IN ST. CLAIR COUNTY, ILL.

The wheat growing on the Marion silt loam gives frequently an abundant crop of straw, but a poor yield of grain, on account of the hardpan cutting off the moisture below during the dry period which comes when the grain is maturing. This soil in other areas has been successfully used for apples.

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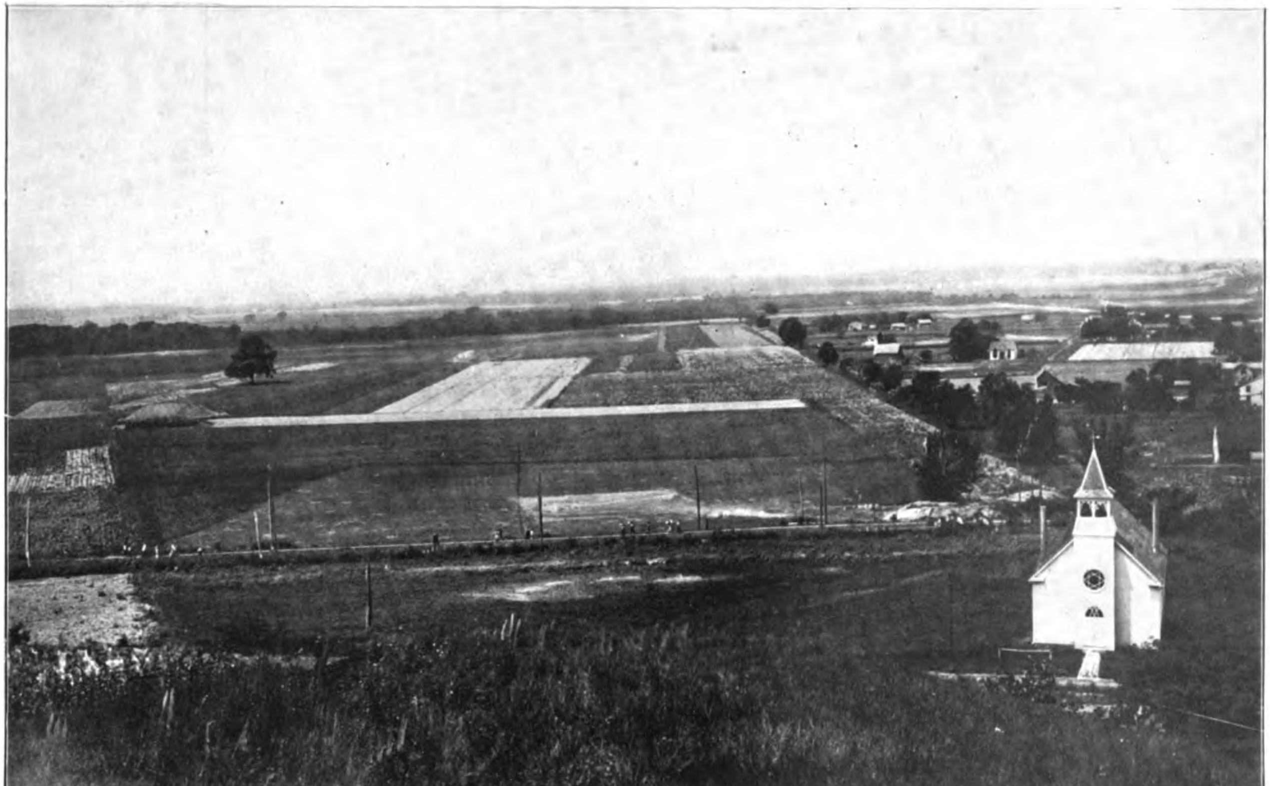

VIEW OF THE AMERICAN BOTTOMS, ST. CLAIR COUNTY, ILL.

A perfectly level plain, at places 40 miles broad, producing magnificent farm crops on a variety of soils. Much of this land is still uncleared and awaiting settlement.

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showed that in many cases 18 per cent more surface is exposed than would be the case if the soil were level. Small-toothed cultivators would undoubtedly waste less moisture, cut off fewer roots, and give better results. The working of organic matter into the soil by the use of manure and the plowing under of green crops will also aid in retaining moisture.

Gang plows and single walking plows are both in common use, but the disk plow is beginning to be used by many farmers. The ground is usually broken as soon as the wheat is taken off. Some farmers thrash the wheat from the shock, while others stack it before thrashing. The former method saves the expense of stacking, but the wheat is liable to be damaged from rains. The wheat is generally hauled to market from the thrasher. Corn was formerly cut by hand, but machinery is now being used quite extensively for this purpose. As soon as the corn becomes dry enough it is husked and cribbed and the cattle are allowed to eat the fodder. Shredders are now being used by many farmers. Little corn is shipped out of the county. Two different methods are practiced in the growing of Irish potatoes. The planting is the same in both cases, but in one method the potatoes are cultivated, while in the other the ridges are covered with a straw mulch as soon as the potatoes are planted and receive no cultivation. Some growers claim that the potatoes grown under a mulch are of a better quality than those which are cultivated in the usual way.

AGRICULTURAL CONDITIONS.

St. Clair County has always ranked as one of the leading agricultural counties in the southern part of the State. The farmers are generally prosperous, as is evidenced in the many well-kept farms. The improvements upon these differ in different parts of the area. They usually consist of a neat, well-built, painted dwelling house, a barn for stock and feed, and outhouses for other purposes. The majority of the farmers have binders, mowers, rakes, plows, and other farm implements, while some have corn harvesters and shredders. Many of them do not provide shelter for these implements, but allow them to remain out in the weather from one season to another.

About one-half of the land in the county is worked by tenants, the proportion being greater in some localities than in others. In the American Bottoms almost all of the land is owned by men who do not live upon it, and the improvements upon the farms here are below the average for the county. Two methods of renting the land are practiced. In one a certain price per acre is paid for the use of the land, the price usually ranging from $3 to $5 per acre, though in some cases, where two or three crops a year are obtained, the rent may be as much as $8 or $10 per acre. This system, while it is most common in the American Bottoms, is also usually followed where the renter

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wishes to use the land for truck, market-garden crops, or pasture. Under the more common system, however, the tenant gives for the use of the land a fixed proportion of the crop, usually one-third, delivered at the market. This plan is generally considered to be more satisfactory both to landlord and tenant. In the average run of seasons full crops are only obtained about six years out of ten, and in seasons of poor crops it is often difficult for the tenant to pay a money rent. Some of these tenants were born and brought up upon the farms which they are now cultivating and look after them very carefully.

The farms of St. Clair County vary in size from a few acres to nearly 500 acres, but 80 acres will about represent the average size. Some men own many farms, so that the average amount to the landowner is above this figure. The farms were formerly much larger, but have gradually decreased in size. The smaller farms are more generally near Belleville and East St. Louis and along the electric railway which connects these two places. The land along this line is being rapidly taken up for suburban residences. The value of the land varies greatly in different parts of the county, due to the difference in the character of the soils, the amount of improvement upon it, its location, and the amount of coal under it. Unless near a railroad the last factor does not affect it very much. The better quality of the land, when well improved, sells at from $75 to $125 per acre, while the poor, unimproved tracts can be bought for $20 per acre. The largest areas of unimproved land lie along the Kaskaskia River and smaller streams and are still timbered. The value is higher near the towns or cities, and some of the land near East St. Louis could not be bought for less than $300 per acre.

The farm laborers are almost exclusively white. Labor is generally scarce, although some farmers say they have little difficulty in obtaining hands. The greatest scarcity is felt at the time of harvesting and thrashing the wheat crop, and considerable loss is sometimes sustained by reason of a lack of labor to harvest it at the proper time. Farm laborers are usually paid from $15 to $20 per month, and are given board and washing in addition. The labor is efficient, and the only difficulty is in getting enough of it.

Wheat, corn, oats, Irish potatoes, orchard fruits, truck, and market-garden crops are the principal agricultural products grown in St. Clair County. Of these wheat is by far the most important, as probably two-thirds of the cultivated land is seeded every year to this crop, while on the Marion silt loam it forms almost the exclusive crop. St. Clair County ranks first among the counties of the State in the number of acres planted in wheat. The wheat produced is of an excellent quality. A greater diversity of crops has been introduced upon the Miami silt loam and Miami fine sandy loam within the last few years, and the acreage in wheat upon these types has been reduced.

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Corn is the crop next in importance to wheat. Very little of it is grown upon the Marion silt loam, as this type of soil is not adapted to it. Oats are grown to some extent, but are generally considered to be an uncertain crop, although some farmers obtain good yields. Since the time of the early settlers Irish potatoes have formed one of the important agricultural products of the county. Large areas, especially in the Mississippi Bottom, are planted in this crop each year, and profitable returns are obtained. Some farmers report as high as 400 bushels to the acre, but such yields are rare and the average is probably less than 75 bushels per acre. Nearly every farmer has a small orchard to furnish fruit for domestic use, but in a commercial sense fruit growing in St. Clair County is in its infancy. This should not be the case, however, as there are large areas along the bluffs and on the hills which are best suited to the production of fruits and where well-cared-for orchards would be very profitable. There is a considerable amount of trucking and market gardening carried on, especially near Belleville and East St. Louis. Cabbages, tomatoes, sweet corn, strawberries, raspberries, and blackberries are grown in considerable quantities and are readily disposed of in the near-by markets. There are still large areas of soil in the county which could be made to yield much larger profits from these crops than are obtained from the crops now grown.

While there has been no attempt heretofore to classify the soils of St. Clair County and to show the areas occupied by each type, a broad classification has been recognized by the farmers and a general adaptation of the crops to the different soil types has been worked out. Experience has shown that the growing of corn is not profitable upon the Marion silt loam, and that wheat does better than any other grain. The possibilities of this soil for the production of fruit has not been recognized, although some fair orchards were noticed upon it. The Yazoo sandy loam is recognized by the growers of early vegetables to be adapted to these crops. Many farmers, however, still grow wheat and corn upon this type. These would undoubtedly find truck and market-garden crops much more profitable. A few instances were noticed where attempts were being made to grow truck crops upon the Yazoo clay, but the condition of the plants did not give promise of very profitable returns.

The development and prosperity of any community depends largely upon its means of communication with other parts of the country. The Mississippi River has always furnished a natural highway into the heart of the United States and has had a great influence upon the development of the country adjacent to it. This influence was much more potent before the building of so many lines of railway. A large proportion, however, of the coal, of the manufactures, and agricultural products of St. Clair County is still carried to market by means of

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barges and steamboats plying this river. Nearly all the great trunk lines of the East and South run into the county and have their termini at East St. Louis, thus furnishing transportation facilities enjoyed by very few counties in the country. The lines which have the greatest mileage in the area are the Baltimore and Ohio Southwestern, which runs east and west through the northern part; the Southern Railway and the Louisville and Nashville, which traverse the central part; and the Illinois Central, which crosses from southeast to northwest. These connect at East St. Louis with all the great lines from the North and West. Electric lines also connect Belleville, East St. Louis, and Caseyville. The first two places are also joined by a good macadamized road—the first one built in the State. Turnpike roads radiate from Belleville in all directions and the entire county is traversed by fair dirt roads. These many excellent systems of transportation give to the farmers of St. Clair County ready communication with all the great markets of the country. The farmers' greatest advantage, however, lies in the heavy local demand for their products. The great city of St. Louis, which is situated directly across the river, consumes each year large quantities of agricultural products. East St. Louis, with a population of over 30,000, and Belleville, with about 20,000, as well as a number of other smaller towns of from 500 to 2,500 inhabitants, also furnish good home markets for the products of the farm.

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SOIL SURVEY OF CLAY COUNTY, ILLINOIS.

By GEORGE N. COFFEY and PARTY, IN COOPERATION WITH THE ILLINOIS EXPERIMENT STATION.

LOCATION AND BOUNDARIES OF THE AREA.

Clay County lies near the center of the southern part of Illinois, about 100 miles directly east of St. Louis. It is situated between west longitude 88° 17′ and 88° 43′ and north latitude 38° 38′ and 38° 55′. About one-half of its eastern boundary is formed by Big Muddy Creek and the Little Wabash River. In shape the county is almost square. Its distance from north to south is 21 miles, and its average width from east to west is about the same. It contains 294,336 acres, or about 460 square miles. (See fig. 13, p. 465.)

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

When the first immigrants came to Clay County the appearance of the country was very different from what it is to-day. The surface was about equally divided between forests and prairie. The former grew along the streams, and the latter occupied the level divides between them. The prairies were wet and miry and in the spring were almost impassable. They had a strong sod, which would hold up a wagon and team, but which would shake for rods around. Upon this sod grew a dense, tall prairie grass. Many ponds existed, and the water generally remained upon the surface until removed by evaporation. These prairies were the breeding place of myriads of flies, which were so troublesome in the early days of settlement that the farmers had to plow at night in order to avoid them. This fact, together with the general unhealthfulness of the prairies, led the early immigrants to take up the timber lands and to leave the prairie lands unclaimed and untouched.

Clay County was not one of the first counties of the State to receive the tide of immigration which flowed into the great West. There was not a settlement within the present limits of the county until 1810, when John McCawley erected his log cabin where the present town of Clay City stands. He was forced to flee for his life during the Indian war of 1812, but returned as soon as the Indians were subdued. The next settlement was made near Flora, in 1818. Although the county did not settle up very rapidly, immigrants, principally from Indiana, Ohio, and Kentucky, continued to arrive, and

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settlement gradually extended until the greater portion of the county was brought under cultivation.

The lack of a natural outlet for the products of the county greatly retarded its development. The Little Wabash River is the only stream of any importance within the area, and it is too small to be of much use for transportation. Small flatboats, however, were built and floated down the river, and upon these were shipped considerable quantities of grain, beef, and pork. The construction in 1855 of the Ohio and Mississippi Railroad, now the Baltimore and Ohio Southwestern, furnished ready communication with other parts of the country and did much toward developing the county's resources.

Corn and wheat were for many years the principal products grown, and the exhaustive system of growing these crops upon the same land year after year caused a deterioration in the soil and a consequent decrease in the yields obtained, until the profit to be made from these crops was much decreased. The growing of hay and the raising of stock were gradually introduced and have proved profitable. The agricultural outlook, however, was not as encouraging as could be desired, and many farmers who were anxious to find some crop that would prove more profitable than the growing of corn and wheat turned their attention to fruit culture. From the time of the earliest settlers nearly every farmer had his small orchard to supply his own needs, but the apple crop did not become of sufficient importance to form one of the principal agricultural resources of the county until about 1883, and even then there were very few large orchards. Since then, however, the fruit business has been very greatly extended, until to-day Clay County ranks as one of the first counties in the Union in the growing of fruit. The fruit industry has infused new life into the agriculture of the area and is doing much to increase the general prosperity of the farmers.

CLIMATE.

The following table gives the normal temperature and precipitation at Flora, a Weather Bureau station in the northern part of the area. The figures show a comparatively uniform precipitation, with the maximum occurring during the growing season:

Normal monthly and annual temperature and precipitation at Flora.

Month.	Temperature.	Precipitation.	Month.	Temperature.	Precipitation.
	° *F.*	*Inches.*		° *F.*	*Inches.*
January	30.4	3.23	August	74.5	3.50
February	31.5	2.87	September	67.8	2.72
March	40.8	3.87	October	55.2	2.28
April	55.0	3.81	November	41.5	3.62
May	63.4	4.25	December	34.4	2.90
June	73.2	4.84	Year	53.5	42.45
July	76.9	4.56			

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During the last two years the last killing frosts in spring have occurred about the middle of April and the first in the fall on September 30 and November 8, respectively. The records of frost occurrence are too meager to form the basis of a calculation of the length of the growing season.

PHYSIOGRAPHY AND GEOLOGY.

The surface of Clay County is that of a broad, level plain, through which the streams have carved out valleys from a few feet to 50 or 75 feet below the general level. The principal stream is the Little Wabash River, which crosses the county in a general southeasterly direction. This river, with its affluent streams, Big Muddy, Elm, and other smaller creeks, forms the natural drainage system, the general direction of which is toward the southeast. The bluffs along these streams generally rise rather abruptly to a height of from 10 to 50 feet or more, the height being greater in the northern than in the southern part of the county. In some cases, as north of Clay City, the ascent is very gradual and there is no sharp line between the bottoms and the uplands.

The erosive agencies have cut out narrow valleys which run back sometimes 3 or 4 miles into the uplands and give to the country along the streams a somewhat hilly and broken character. Between the streams level to gently rolling prairies extend, often for many miles. The general elevation of the county above sea level is about 500 feet.

Along many of the streams outcrops of the underlying rocks, which belong to the upper Coal Measures, were seen. These rocks are sandstones, sandy black shales, and limestones. Some thin seams of coal are found in these rocks, but they are not thick enough to be of much commercial importance. The seams of coal which are worked in St. Clair and other counties farther west probably underlie Clay County at a depth of from 800 to 1,000 feet below the surface, but they have not as yet been worked. Sandstones of fair quality for building purposes are found at several localities, and a few quarries were observed. Bands of iron ore are also intercalated in the beds of shale.

These underlying rocks have very little influence, at least directly, upon the character of the soil, for they are buried beneath a deposit of glacial drift. As the surface of the country was more or less eroded and uneven before the Glacial epoch, the depth of the drift varies in different localities from 10 to 40 or more feet. Only in a few very small areas has the glacial material been entirely removed. At Xenia and Flora this drift is 13 to 14 feet thick, and in wells bed rock is struck generally at 10 to 20 feet. The lower portion of the glacial material usually consists of a hard bluish or ash-gray clayey stratum, which is sometimes termed "hardpan." The upper part is composed of a reddish-brown, gravelly, sandy till, the percentage of

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gravel and sand decreasing toward the upper part until at 4 to 6 feet below the surface they are almost entirely absent. This material is composed largely of the ground-up sandstones, shales, and limestones of the Coal Measures, while fragments of granites, quartzites, and syenites are not uncommon, and occasional nuggets of copper are met with.

SOILS.

Clay County does not possess a great variety of soils, only four different types being recognized. The names of these, with the area occupied by each, are given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Marion silt loam	260,544	88.5	Yazoo sandy loam	1,344	0.5
Waverly silt loam	30,976	10.5	Total	294,336	
Yazoo loam	1,472	.5			

YAZOO LOAM.

The Yazoo loam is a slightly granular brown loam containing a considerable amount of organic matter, which gives it its dark color. It is sometimes slightly sandy near the river or near the Yazoo sandy loam. This character of material extends to an average depth of 9 inches and is underlain by a yellowish, friable, silty, and fine sandy loam, in which the sand content gradually increases with the depth until at about 24 inches below the surface it becomes a sandy loam and often almost a sand. The lower-lying sandy material is usually stained in spots by iron.

This type of soil is found in small, narrow, disconnected areas in the Little Wabash bottom. It does not occur frequently along the lower reaches of the river. It occupies a small percentage of the total area of the county, but ranks first in value for general agricultural purposes.

The surface features of the Yazoo loam are very similar in all the area. It is generally level, with slight elevations and depressions. It is somewhat cut up by old stream channels or washes made during times of high water, its elevation above the river not being sufficient to secure it against overflow.

The sandy character of the underlying material gives to this soil excellent natural drainage, and artificial drainage is seldom necessary. The Yazoo loam has been formed from the sediment deposited by the Little Wabash River during periods of overflow. It is strictly an alluvial soil and has in a high degree the natural fertility of this class of soils.

Probably two-thirds of the area occupied by this soil type has been

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cleared and brought under cultivation. Corn forms almost the exclusive crop. The yield is about 50 bushels per acre. Hay, wheat, sorghum, and broom corn are also grown, and good yields are obtained. This soil is well adapted to the growing of the crops named and for general farming purposes. Its liability to overflow, however, has to be considered in calculating the profits to be reaped from it.

The following table shows the texture of typical samples of the soil and subsoil of this type:

Mechanical analyses of Yazoo loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7391	8 miles NW. of Louisville.	Brown sandy loam, 0 to 9 inches.	4.12	0.34	1.56	1.20	4.14	7.86	60.86	23.24
7392	Subsoil of 7391......	Silty and sandy loam, 9 to 36 inches.	.97	.18	1.18	1.02	2.84	14.06	63.66	16.26

YAZOO SANDY LOAM.

The texture of the Yazoo sandy loam varies considerably, being more sandy in some places than in others. The general character is that of a fine sandy loam with the sand content rather high, 12 inches deep, and pale yellow or gray in color. The soil does not contain a large amount of organic matter, as its light color indicates. The subsoil consists of a fine sandy loam, also of high sand content, slightly heavier than the soil.

This soil is found in narrow strips along the Little Wabash River, occurring in small, disconnected areas along its banks, especially in the bends of the stream. It occupies only a small proportion of the area of the county, the greater portion of it lying north of Louisville, although a few scattered areas are found along the river south of this place. The surface of this soil may be described as generally level, with low ridges and shallow intervening depressions, a configuration due to flood action.

As is generally the case along streams, the elevation near the banks of the river is greater than back near the bluffs, and so the Yazoo sandy loam lies slightly higher than the other bottom soils. This fact, together with its sandy character, gives it excellent drainage. In fact, its open, porous nature and unretentiveness of moisture sometimes cause crops to suffer from drought.

It is a well-known fact that the carrying power of water decreases

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rapidly with a decrease in the velocity of the current. When a stream overflows its banks the current is checked by weeds, bushes, etc., and by friction against the surface of the ground. With the slacking of the current sedimentation is increased, the coarser material being deposited first. It is of the coarser particles carried by the river that the Yazoo sandy loam has been built up, and it is because of the coarseness of the particles that the areas of this soil occur in narrow strips along the banks. The sand is very largely composed of quartz which has been derived from the weathering of the glacial material and washed into the river by its tributaries.

Corn forms the chief crop grown upon this type. The smallness of the area renders it almost impossible to obtain anything like an accurate estimate of the average yield. Fair crops are produced, however. Some sorghum, broom corn, watermelons, and tomatoes are also grown. This soil is rather too light and sandy for corn, but is well adapted to the growing of truck crops, and it is often sought out for this purpose. There is, however, more liability of damage from overflow to early truck than to corn. The floods usually come early in the spring, and there is little doubt that at least late truck crops could be made more profitable than corn.

The following table shows the texture of this soil:

Mechanical analyses of Yazoo sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7393	2 miles NW. of Louisville.	Brown sandy loam, 0 to 10 inches.	1.27	0.00	0.10	2.16	29.10	20.52	34.32	13.70
7394	Subsoil of 7393......	Sandy loam, 10 to 36 inches.	.53	.00	.02	3.26	36.34	21.26	28.52	10.60

WAVERLY SILT LOAM.

The surface soil of the Waverly silt loam consists of a light-brown to whitish, very silty loam with a depth of 10 inches. In a few places the soil contains enough organic matter to give it a brown color, but typically it ranges in color from gray to almost white. It also has usually a somewhat mottled appearance, light spots being intermixed with darker ones. When dry and recently cultivated it is very loose and dusty, but the particles run together after a rain. The subsoil, which is a silty loam, heavier than the soil, is often called clay, but this term is not well applied. It is of a whitish or mottled color, often

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stained with iron. This character of material extends to a depth of several feet.

The smaller areas, occupying old lake beds in the northwestern part of the county, are somewhat heavier in character and of better quality than the average of this type.

This type of soil occupies the greater portion of the bottom lands of Clay County. It is found along the Little Wabash River and all of its affluent streams. The bottoms are much wider in the lower than in the upper portion of the river. The largest area is found east of Clay City, between the Little Wabash River and Big Muddy Creek.

The surface of this soil is generally level and the areas it occupies are sometimes called "water-oak flats." Sloughs and old stream channels dissect it in many places, and it is lower at the foot of the bluffs than near the streams. This fact, together with the level character of the surface, gives this soil rather poor natural drainage. The old stream channels, however, help to carry off the water. The river, in periods of high water, breaks over its banks at some low place, or backs up from below, so that the bottom land farthest from the streams is overflowed before the higher-lying areas nearer the streams. After floods the water remains in some places until carried away by evaporation, but there is very little of this type which can not be drained, and much of it could be improved by drainage.

The Waverly silt loam is an alluvial soil and represents the material which has been washed off the uplands, brought down by the streams, and deposited in comparatively quiet water. In character it is very much like the Marion silt loam, being composed of the same glacial material modified by stream action.

Corn is the principal crop grown on the Waverly silt loam, as well as on the other bottom soils, and averages about 30 bushels to the acre. Some farmers, however, report yields much above this average. Hay is also grown and produces three-fourths of a ton to the acre. Some wheat and oats are also sown. Probably 50 per cent of this soil type is still in forest, oak largely predominating. This type seems to be as well adapted to the crops principally grown (corn and hay) as to any others, but it should not be used for these crops exclusively. It is not a strong soil and generally contains a relatively small proportion of organic matter. Cowpeas are used to a limited extent by some farmers and are of undoubted benefit to the soil and should be more extensively grown. The soil is not very retentive of moisture, and crops are apt to suffer in dry weather. The incorporation of more organic matter into the soil would improve it in this respect.

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The following table gives mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Waverly silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7385	2¼ miles E. of Clay City.	Silty loam, 0 to 10 inches.	1.71	0.74	2.62	1.14	2.66	7.56	62.58	22.06
7387	3 miles N. of Hord..	Brown silty loam, 0 to 10 inches.	1.99	.34	1.60	1.56	5.14	4.94	61.54	24.04
7389	2¾ miles SE. of Louisville.	Brown silty clay, 0 to 12 inches.	1.88	.34	1.66	1.38	4.16	8.42	56.18	27.24
7386	Subsoil of 7385......	Whitish silty loam, 10 to 36 inches.	.48	.90	2.46	.94	1.50	7.72	65.36	20.58
7388	Subsoil of 7387......	Mottled-gray silty loam, 10 to 36 inches.	.62	.06	.82	1.04	3.64	4.82	66.68	22.24
7390	Subsoil of 7389......	Silty loam, 12 to 36 inches.	.93	.96	1.72	.84	2.88	7.40	57.72	27.80

MARION SILT LOAM.

The Marion silt loam consists of a light-brown to whitish, very silty loam with a small percentage of organic matter. It has an average depth of 12 inches. It also contains some very fine siliceous sand, and in fact the entire soil is composed largely of silica. A small percentage of shotlike concretions of iron are also present. After a rain the soil becomes rather hard, but when stirred and pulverized it changes into a fine, floury dust. Certain areas, known as "post-oak lands," are whiter and contain less organic matter than the typical soil. This soil grades gradually into a layer of white siliceous silt and very fine sand, which also shows a small percentage of iron concretions. This white layer is usually called "hardpan," although it is not a true hardpan, but crumbles quite readily between the thumb and finger. It is thicker in some places than in others, and occasional areas are found where it is entirely absent. This is most often the case near the streams or other places where there is good drainage. There is a sharp line of demarcation between this layer of white material and the underlying true subsoil. The subsoil is heavier and contains more clay, as is shown by the mechanical analyses, but the difference in the character of the soil and subsoil is greater than one would expect from the analyses. From a depth of 20 inches to 4 or 5 feet the subsoil consists of a rather hard, impervious, very silty mottled-yellow clay. In some cuts along the roads outcrops of this material had become almost as hard as brick, and contained many iron concretions. At 4

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or 5 feet a small percentage of glacial gravel is struck, and the gravel content increases with the depth. This gravel is found outcropping along nearly all of the streams. The subsoil is more tractable and less impervious in the timbered areas than on the prairies, due probably to the better drainage conditions which exist there.

There are a few low ridges in the area upon parts of which the soil is somewhat different from the general type. It is more loamy, the white layer between soil and subsoil is often absent, and the subsoil is redder and contains more sand.

The Marion silt loam is a very extensive type of soil, occurring in broad areas and covering the entire uplands of Clay County. It occupies about 88 per cent of the entire area. It is also found in all of the adjoining counties and covers a larger area in this portion of the State than any other soil.

The surface is generally level to slightly rolling, although near the streams it is somewhat broken and hilly. A few low preglacial ridges also occur, the most prominent of these being south of Clay City and north of Xenia.

As before stated, when the first settlers came to Clay County the level uplands were wet and swampy, with many ponds scattered about over them. The area has now all been drained, either by natural or artificial means; but even now, after heavy rains, especially in the winter and spring, water stands for several weeks upon some of the more level areas. Many instances were noticed where the fields were plowed in narrow lands in order to provide surface drainage. The rather impervious nature of the subsoil does not let the water soak readily into the ground, and the surface is often too level for it to flow off quickly, and it is therefore necessary to provide drains to carry away the surplus. Very little underdrainage of the soil has been done, but there is little doubt that it improves the land, although the cost is considerable because the drains have to be put rather closely together. Areas near the streams have good natural drainage.

The Marion silt loam in Clay County has been formed directly from the weathering of the débris left by the ice during the advance known as the Illinois glaciation. Before this advance of the ice the surface of the country for many miles to the north was formed by the rocks of the Coal Measures, consisting principally of sandstones, shales, and limestones, with thin seams of coal and bands of iron ore. As the ice moved over these rocks, portions of them were ground off and transported southward. An examination of the glacial gravel shows it to consist chiefly of these rocks. Sandstones and shales are composed very largely of the insoluble, or very slightly soluble, residue of the igneous rocks, and a soil derived from these sedimentary rocks would be relatively low in plant food and high in silica, characteristics which the Marion silt loam possesses to a marked degree. The large

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amount of iron which is present in the soil came principally from the bands of iron ore which were ground up along with the rocks in which they were bedded.

Corn, hay, and fruit are the principal products grown upon the Marion silt loam. Wheat, oats, sorghum, broom corn, and cowpeas are also grown. A few small patches of tobacco were seen. The average yield of corn is not much more than 15 bushels per acre, although the crop this year (1902) will probably average nearly twice that quantity. Hay produces about three-fourths of a ton per acre. Broom corn does fairly well, and the quality is said to be very fine.

The Marion silt loam is not a strong soil and is not well adapted to general farming purposes. The small yield of corn indicates that it is not a good soil for that crop, although the profit from corn, according to many farmers, is as much as from other crops. Redtop grass is a very important product and the soil seems to be fairly well adapted to it. Timothy also does well. There is no crop, however, so far as experience goes to show, to which it is any better adapted than fruit, and fruit growing is now one of the most important industries in the county. (See Pl. XXIX.)

The uniformly light color of this soil shows it to be deficient in organic matter, and an effort should be made to supply this by means of stable manure and the growing of leguminous crops. Many of the farmers grow cowpeas for the double purpose of providing forage and improving the soil, and this practice is to be highly commended.

The following table gives mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Marion silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7370	1¼ miles N. ¼ mile W. of Biblegrove.	Silty and sandy loam, 0 to 12 inches.	1.75	0.26	2.40	2.78	5.26	2.90	70.08	15.52
7379	4 miles W. of Louisville.	.....do...............	1.63	.04	1.64	1.80	3.84	6.36	67.24	18.14
7373	1¼ miles N. of Flora.	Light-gray silty loam, 0 to 12 inches.	1.49	.24	1.80	2.42	4.98	2.84	68.52	19.18
7371	Subsoil of 7370......	Silt and sand, 12 to 18 inches.	.77	.98	2.16	2.48	4.70	2.88	69.54	17.24
7380	Subsoil of 7379......	.....do...............	.48	.98	2.24	2.40	3.40	5.84	66.60	18.06
7374	Subsoil of 7373......	Silt and sand, 12 to 20 inches.	1.34	.60	1.70	2.82	5.44	7.10	61.14	20.66
7375	.....do.............	Silty clay, 20 to 36 inches.	.54	.60	1.28	2.18	4.24	5.70	58.32	26.94
7372	Subsoil of 7370......	Silty clay, 18 to 36 inches.	.82	.28	1.42	1.78	3.14	1.92	60.90	30.32
7381	Subsoil of 7379......	.....do...............	.29	.44	1.04	1.24	2.74	4.32	50.48	39.30

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THE HARDPAN PROBLEM.

One of the most important soil problems of Clay County and the surrounding region lies in the hardpan stratum of subsoil of the Marion silt loam. This term "hardpan," as used in the area surveyed, refers sometimes to the whitish layer between the soil and the true subsoil, and sometimes to the hard, rather impervious subsoil itself. It is believed by some that the impermeability of the Marion silt loam is due to the white layer, but the writer, for reasons which will presently appear, inclines rather to the opinion that it is due to the underlying layer, and that the presence of the white layer is simply the result of the impervious character of the underlying subsoil.

This so-called hardpan greatly impairs the agricultural value of the land. Its injurious effects are chiefly felt in two ways, namely: It hinders the development of the roots and prevents the maintenance of proper moisture conditions, the soil seeming to be capable of holding but a very small moisture reserve. Water percolates through the hardpan layer very slowly, and this layer is easily puddled and in that condition holds water like a pan.

The texture of the subsoil, as shown by the mechanical analyses, is not such as would indicate as impervious a character as is possessed by this soil, and the reason, or reasons, for this marked characteristic is not evident. There are two explanations which suggest themselves: Either the condition might result from an impervious layer beneath the soil, or else from some peculiarity in the structure of the soil itself. An examination shows that there is no impervious layer below the subsoil that could cause the condition, and so one must conclude that it is due to some peculiarity in the structure.

Iron is always more or less abundant, and in some cases is present in sufficient quantity to form almost an iron "hardpan." It is seen in both soil and subsoil in the form of iron concretions, and wherever the iron appears to exist in the greatest quantity there the subsoil seems most impervious. The presence of so large an amount of iron in the soil has already been stated as probably due to the fact that the glacial material here was derived principally from the rocks of the coal measures, which contain bands of iron ore as well as ferruginous sandstones. It may be that the presence of the iron gives the soil its impervious character by filling up the small spaces between the soil grains and by more or less coating and cementing them together, so that the water can not readily pass through the resulting loosely bound conglomerate.

It was noticed that wherever there was good drainage, as, for instance, near the streams, the subsoil appeared to contain less iron and was more pervious. The fact was also observed that the bottom soils here, which have been formed by the wash from the uplands, contain many

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indications of the presence of large amounts of iron. On the slopes where the water can drain off readily through the soil the iron has undoubtedly been partially leached out and later deposited in the bottoms, so the soil on the slopes contains less of it, while on the level areas, where there is very little opportunity for the water to drain out through the subsoil, the mineral remains in larger quantities.

If the close structure of this subsoil is due to the presence of iron, the land could be improved by underdrainage. Iron compounds are not, however, readily soluble, and the improvement would therefore be rather slow, but would increase gradually as the iron was removed, the soil becoming more and more permeable.

The Marion silt loam is also in general an acid soil, as has been shown by examinations made in the laboratories of the Bureau of Soils. This acidity can be readily corrected by the use of lime or by underdrainage, or, best, by a combination of the two.

AGRICULTURAL METHODS.

The methods which have been too generally practiced in Clay County have tended toward the exhaustion of the soil rather than to the maintenance of its productiveness. Nearly all the farmers say that they can not produce as large yields now as formerly. This is due largely to the removal of organic matter from the soil, which has resulted not only in a decrease in the available supply of plant food, but in a change of texture lessening the capacity of the soil for moisture and interfering with perfect aeration.

The grain crops are generally fairly well cultivated, but many of the orchards appear to be almost entirely neglected so far as care of the soil is concerned. Weeds have been permitted to grow and have done much damage to the trees. The soil in an orchard should be thoroughly and repeatedly stirred in order to secure the best results, and, according to the best authorities, small grain and grass should have no place there. The cultivation of the soil is as essential to the proper development of fruit trees as it is to the production of grain and other field and garden crops. Many fruit growers have realized this fact and have their orchards in good condition. Even where cultivation is attempted one of the most common practices is to plow only in one direction, thus leaving a strip between the trees uncultivated. It is much better to plow both ways, turning the furrows alternately toward and from the trees.

Aside from fruit, corn and hay form the principal crops, and most farmers plan to keep the land in these the greater part of the time. The general practice is to sow the land in grass and allow it to remain in sod until there is a material decrease in the yield of hay. The average period for which fields are thus kept in grass is perhaps four or five years. The sod is then turned and the land planted in corn for

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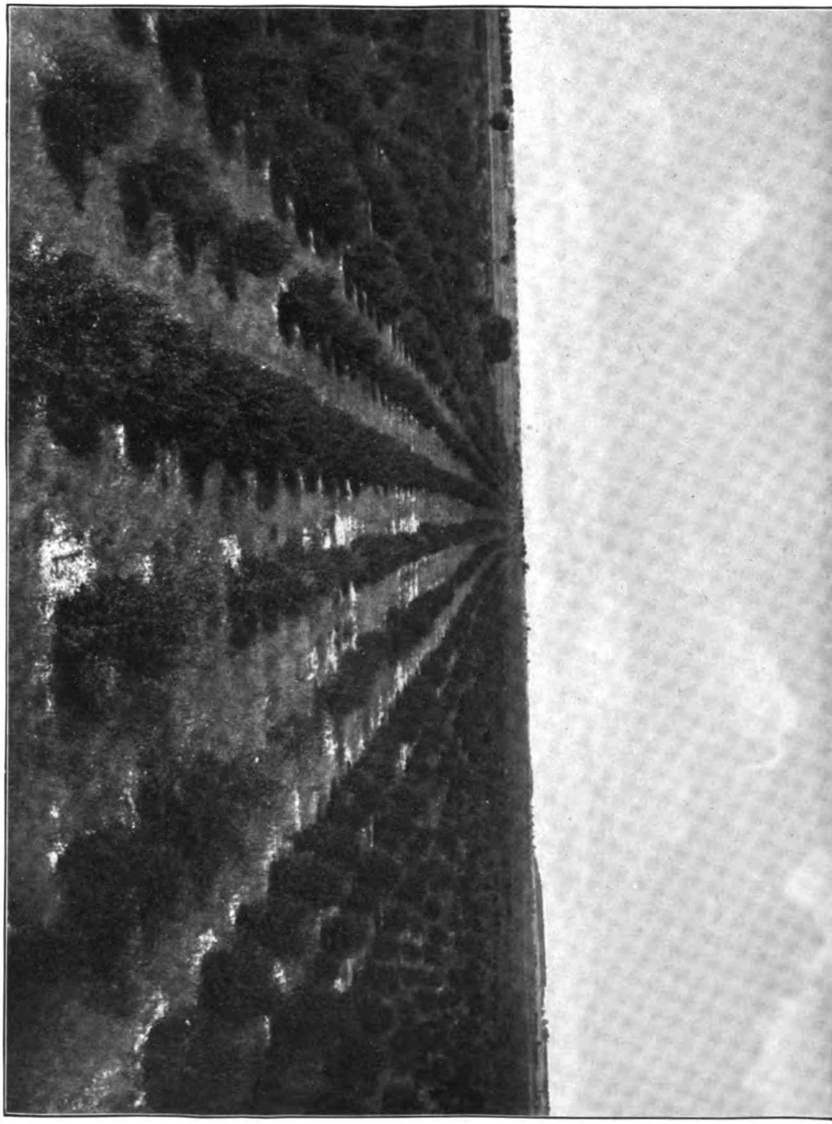

AN EXTENSIVE APPLE ORCHARD ON THE MARION SILT LOAM, CLAY COUNTY AREA, ILLINOIS.

This soil, having a hardpan from 12 to 18 inches below the surface, is poorly adapted to farm crops, but has been shown to be admirably adapted to apple trees, which are set out in holes dug through the hardpan.

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two or three years successively, then sowed in oats or wheat for one year, in order to get the soil in proper condition to sow in grass again. Some farmers keep their land in corn for a much longer period than that stated above. This is the general rotation practiced upon the upland, while on the bottom lands corn is grown almost exclusively. This system is a rather heavy drain on the soil. No system of rotation should be considered which does not include a leguminous crop. Cowpeas produce fairly well and should be grown more extensively.

AGRICULTURAL CONDITIONS.

The prosperity of any agricultural community is dependent largely upon the character of the soil, as well as upon the climate, market facilities, character of the people, and other factors. Clay County was not blessed with a very fertile soil to begin with, and the profits from the growing of the staple crops have not been as great as in some other areas, but the fruit industry has become one of great importance within the last few years, and is bringing thousands of dollars into the county and adding to the general prosperity of the farming class. Many of the farmers have substantial, well-built residences, with good barns and outhouses. The average dwelling house is not, however, very expensive, but is neat and shows evidences of prosperity. A number of fine herds of cattle were noted, and much more attention is being given to stock raising than formerly. In an area where so much hay is grown the raising of stock should be one of the chief industries. The hay should be fed to the stock and the manure put upon the land. In this way the original fertility of the soil could be more nearly maintained.

The majority of the farms are owned and tilled by the farmers themselves. Many of them, however, are cultivated by renters, who usually pay a grain rent. One-third of the crop is the proportion generally taken by the landlord, but when the tenant wishes to grow hay, one-half the crop is required.

About 25 per cent of the land in Clay County is yet unimproved. There are a great number of small farms of from 10 to 40 acres, and the average size is probably a little less than 60 acres. There are also a large number ranging from 120 to 320 acres, and a few farmers own more than an entire section. The price of farm lands varies much, depending upon the improvements, location, and the percentage which is in orchard. Some of the orchards will sell for $75 or $100 an acre, and the best lands without orchard will bring $30 to $40 an acre. The average assessed value of the improved land of the county is $4.27 an acre, while of the unimproved it is $1.71 per acre. Lands in this State are assessed at 20 per cent of their actual value, so the real average value for the county is about $20 an acre.

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The labor employed is generally home labor. Many farmers do not find it necessary to employ any help in cultivating their crops. Some men who own small farms or who live on rented land do day labor for a part of the time. There is some difficulty in obtaining farm labor, especially during the harvesting season. The apple crop this year (1902) is very large, and it has been hard for the growers to obtain hands to help harvest the crop. The wage of labor ranges from $1 to $1.75 a day.

General farming and fruit growing are the principal agricultural industries of Clay County. Corn is cultivated by nearly all the farmers, but the soil of the uplands, as before pointed out, is not well adapted to this crop. There are no grain elevators in the county, and very little corn is shipped. The chinch bugs do much damage to corn, especially when near a field which has been in wheat. The farmers have almost ceased to raise wheat on account of this pest.

The production of hay ranks among the first of the industries of Clay County. Quite a little timothy hay is cut, especially in the northeastern part of the county, but red top is the variety of grass principally grown, and is considered one of the best-paying crops. It is not grown for the hay alone, but also for the seed. An acre will produce on an average about three-fourths of a ton of hay and about 7 bushels of seed. The hay or straw is better than before thrashing, as the dirt is all blown out of it. It makes fairly good feed. The hay sells for $4 per ton, which pays for cutting the grass and thrashing the seed. The value of the seed, which is about $5 per acre, will thus be clear profit. The fields are often used for pasture after the crop of hay is taken off.

Reference has already been made to the great interest which the farmers of Clay County have taken in the growing of fruit. Twenty-five years ago there were only a few small orchards, but to-day conservative estimates give the area in orchards as 30,000 acres, which places Clay County in the front rank of apple-producing counties of the United States. In 1883, the first year the apple crop was of sufficient proportions to become of commercial importance, 17,042 barrels were shipped from the county. During the season of 1902, according to estimates of the Flora Commercial Association, there were produced 272,770 barrels, with a value of $281,485. It is thus seen that there has been a very large increase. The inferior fruit is sold to the evaporators. The peelings and cores are also dried, so that nothing is allowed to go to waste. There are 9 large evaporators in the county. They pay from 10 to 25 cents per bushel for apples.

Different methods of disposing of the fruit are practiced by different growers. Some sell the fruit on the trees and the buyer picks only such apples as he wishes to ship, while others pick their fruit and ship it themselves. The most common practice, however, is for

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the grower to pick the apples and deliver them at the sorting table, where they are graded and packed by the buyer. The price necessarily varies, but $1.25 per barrel is about the average price for the unbarreled apples and $1.75 to $2 for barreled fruit delivered at the cars. A large cold-storage building is being constructed at Flora with a capacity of 18,000 to 20,000 barrels. The apples are picked by hand, carried in baskets to tables in the orchard, and there graded and barreled.

The Ben Davis is the variety which largely predominates, though the Jonathan is also a prime favorite. Grimes Golden, Rome Beauty, Winesap, and many other varieties are also grown, though in much less quantities. The bitter rot is doing much damage to the fruit and is causing a loss of thousands of dollars to the growers. The cankerworm also causes considerable trouble, but this pest can be controlled by spraying.

Some fruit growers claim that little profit is being made from the growing of fruit, while others are undoubtedly obtaining handsome returns upon their investment. One average orchard of 25 acres near Flora, which has been planted fourteen years, has paid $125 per acre, or an average of a little more than $800 per year for the entire period it has been set out. The land was cropped until the trees were 7 years old, and the returns from this source were not taken into consideration. Another orchard of 40 acres was bought two years ago for $1,100. Last year the apples sold for $400 and this year the product of 20 acres brought $800. Some orchards in good years will pay $100 per acre, and an instance is known where $250 per acre was obtained from one orchard for two different years. These instances are given to show what profits have actually been made by some growers.

Other fruits besides apples are grown, but to a much less extent. Many pear orchards were noted, and where the trees have not been injured by the blight profitable yields are obtained. The blight, however, has done a great deal of damage, and the injury from this disease is so extensive that many farmers have abandoned the growing of pears and are cutting out the trees. Peaches are also grown with profit.

In order to make a success of fruit growing it is necessary to give much care and attention to the trees. The proper management of an orchard requires considerable knowledge and experience, and this had to be acquired by the farmers, as very few of them had had any training in the growing of fruit. With the knowledge gained from experience better results will be obtained and handsome profits will be secured by those who give to their orchards the proper care and attention.

The general uniformity in the soils of the county does not give an opportunity for a great diversity of crops. The farmers generally

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have recognized that the Marion silt loam is not well adapted to the growing of wheat and corn, although large areas are still planted to corn. Its adaptability to the growing of fruit is now a matter of common knowledge. The small areas of Yazoo sandy loam are sought out by many farmers for the growing of truck crops.

Clay County has good transportation facilities. The Baltimore and Ohio Southwestern Railroad crosses the southern part of the county in an east and west direction, and also in a north and south direction. The Illinois Central touches the northwestern corner and serves as an outlet for the products of that part of the county.

While the area is not situated in close proximity to any of the great markets of the country, St. Louis is only about 100 miles west, Cincinnati less than 250 miles east, and Chicago about the same distance north. Direct lines of railroads connect the area with these great cities, as well as with many smaller cities, so that the products of the county can be readily and quickly put upon the market.

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SOIL SURVEY OF THE JANESVILLE AREA, WISCONSIN.

By JAY A. BONSTEEL.

LOCATION AND BOUNDARIES OF THE AREA.

The area described in the present report is covered by two topographical sheets of the Geological Survey, known as the Janesville

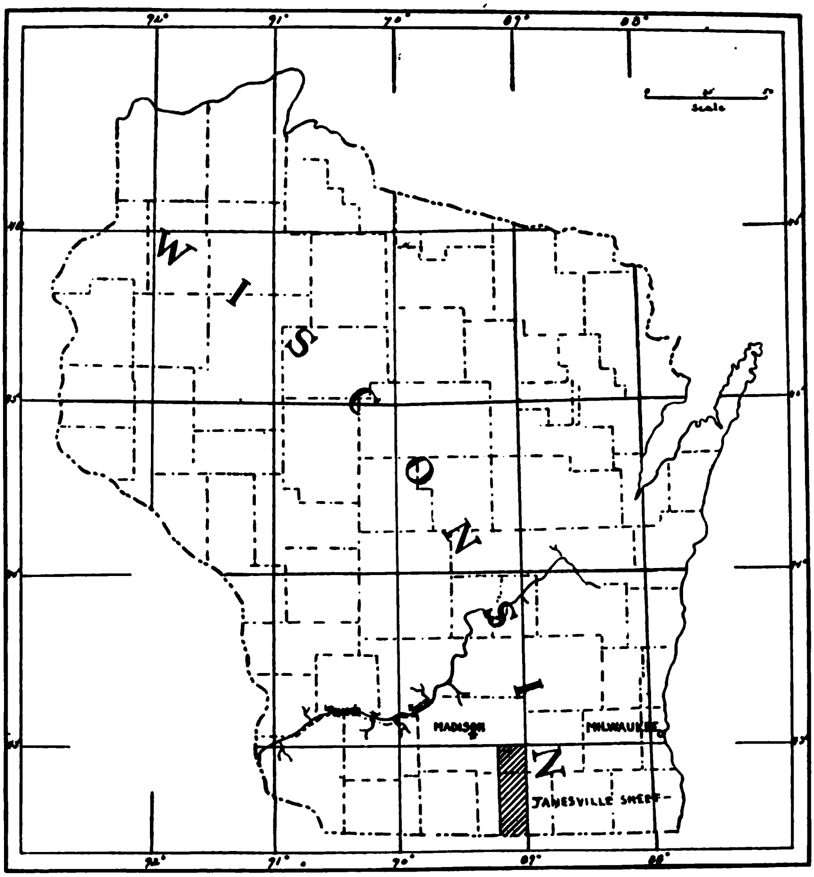

FIG. 14.—Sketch map showing area surveyed in Wisconsin.

and Stoughton sheets. Each of them includes an area 30′ long by 15′ broad. The area extends from the Wisconsin-Illinois State line, 42° 30′ north latitude, to 43° north latitude. It slightly exceeds 450 square miles in extent. It comprises all of the townships of Beloit, Newark, Rock, Plymouth, Janesville, Center, Fulton, and Porter, in

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Rock County, and all of Dunkirk and Albion, with the greater part of Christiana and Pleasant Springs townships, in Dane County. The eastern and western borders of the area overlap the limits of the above-mentioned townships by about a half mile. The important manufacturing cities of Janesville, Beloit, Edgerton, and Stoughton lie within the area. It is crossed by both the Chicago and Northwestern and the Chicago, Milwaukee and St. Paul railroads. Rock River and Yahara River flow across the area, furnishing water power at many points. Lakes Kegonsa and Koshkonong border on the area. (See fig. 14.)

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The country of which the Janesville area forms a part was first discovered and explored by French fur traders and Catholic missionaries. It lay on the border of the territory occupied by the Illinois Indians until their final disappearance before Iroquois war parties. The earliest Indian occupants found by the white men consisted of bands of Winnebago and Potawatomi. Villages of the Winnebago were located at Beloit, near Janesville, at the mouth of the Yahara River, and on the banks of Lake Koshkonong. Besides hunting and fishing these tribes raised small amounts of maize.

Until 1832 only a few scattered trappers and hunters of the white race had ever visited the Rock River country. In that year the army of General Atkinson, sent to defeat and punish Black Hawk, chief of the Sacs and Foxes, marched through this region, encamping at various points in the present area. After the successful termination of this campaign many of the soldiers engaged in it, returning home, told of the fertile prairies and "oak openings," of the abundant water supply, and the beautiful lakes they had seen. This carried the first definite knowledge of the country to the outskirts of civilization, and the pioneers, easily persuaded of a better land just beyond, started forward to the new region. In 1835 John Inman, of Pennsylvania, and William Holmes, of Ohio, made an exploring trip to the junction of the Rock and Yahara rivers. They returned there in the fall of the same year, accompanied by Thomas and Joshua Holmes, Milo Jones, and George Follmer. Samuel St. John and his wife, the first white woman to reach the area, came the same year, and were followed in 1836 by Dr. James Heath and wife. Their settlement was made on Rock prairie, south of the present town of Janesville. This same year, 1835, a Government land office was opened at Green Bay and the first sale was made of land west of Rock River. In 1839 a land office was established at Milwaukee and the land east of Rock River was sold.

In the early days of settlement grain constituted the largest part of the farm produce. Wheat, corn, barley, oats, and rye were raised. Produce was marketed at Chicago or at some one of the Illinois towns

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shipping grain down the Mississippi River. Manufactured articles were brought in by way of the Great Lakes. In 1845 the publication of the first newspaper was begun, and in 1850 the first railroad reached the area. Since these events flourishing cities have grown up, ample facilities for transportation have opened broad markets, and the population of the area, both urban and rural, has greatly increased. The production of wheat has steadily decreased, while that of oats and corn has as steadily increased. The old dependence upon grain as an export crop has passed away. The grains now produced are chiefly fed to live stock, while tobacco forms the most important money crop. Probably there are as many farmers buying grain for feeding as there are selling grain for export. The result is easily seen in the productive fields and well-kept farms.

CLIMATE.

The following table gives the normal monthly and annual temperature and precipitation as compiled from records of the Weather Bureau station at Beloit:

Normal monthly and annual temperature and precipitation.

Month.	Temperature.	Precipitation.	Month.	Temperature.	Precipitation.
	°F.	*Inches.*		°F.	*Inches.*
January	18.4	1.90	August	70.6	2.86
February	20.8	1.30	September	62.4	3.60
March	31.8	2.16	October	50.4	2.40
April	48.0	3.30	November	35.1	2.00
May	57.8	3.88	December	25.0	1.93
June	69.0	3.80	Year	46.9	32.68
July	73.3	3.55			

The average date of last killing frost in spring at Beloit is May 6, and of the first in fall is October 3. This gives an average growing season for tender vegetation of one hundred and fifty days. The latest killing frost of spring to occur since 18[illegible]3 came May 20, 1895, and the earliest in fall September 20, 1896, and on the same date in 1897.

PHYSIOGRAPHY AND GEOLOGY.

The topography of the Janesville area is that of a typical glaciated area where neither glacial erosion nor glacial deposition has completely obliterated preglacial erosion features. It is a region of low, rounded hills and ridges interspersed with broad, flat valleys and stretches of level prairie bordering the major streams in poorly defined terraces. The altitude of the area above sea level ranges from about 740 feet near Beloit to a maximum of over 1,100 feet upon the highest hills in

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the Dane County portion of the area. There is no constant relationship between the topography and the distribution of the soil types, nor is there any definite arrangement of the soil types according to geological derivation. The general trend of the hill masses corresponds to old subaerial erosion forms fixed by preglacial erosion.

Rock River is the principal stream draining the area. Its chief tributaries are the Turtle River, the Yahara River, Marsh Creek, and Bass Creek. Koshkonong Creek flows into Lake Koshkonong. Rock River flows in a deep-cut channel between hills and past bordering terraces of open prairie. Its banks are formed in part by cliffs of sandstone and limestone, in part by gentler slopes of glacial till, and in part by narrow, low-lying strips of meadow land formed largely by wash from higher levels. This stream carries a considerable volume of water, which is utilized at many places for milling purposes. The Turtle and Yahara rivers, though of much smaller volume, are very similar. They are both utilized for water power. The remaining streams of the area are insignificant in size and flow through large tracts of meadow and marsh land. Throughout the area there are many small lakes and ponds, and portions of Lake Koshkonong and Lake Kegonsa are included in the map. Many gravel knolls and ridges, distributed seemingly at random throughout the area, indicate former locations of subglacial drainage which, roofed and walled by the ice sheet then existing, forced their content of water, sand, and gravel across the country with little regard for topography, like huge natural flumes or pipe lines. When the ice disappeared from the surface of the country the traces of these old channels were left in their gravel deposits, called "eskers" by the glacial geologists. Similarly the ice left behind it as it melted the finely ground detritus, derived partly from areas farther to the north and partly from local underlying rock, in the form of a continuous sheet known as the till. In the long years which have succeeded the withdrawal of the ice this till has been prepared by the frost, the rain, and the encroachment of vegetation; that is, through the natural processes of weathering, for the purposes of agriculture. This till thus constitutes the material from which the majority of the soil types of the area have been derived. One other form of glacial deposit is well represented in the area. During the withdrawal of the glacial ice there were numerous halts, when the glacier front stood for some time nearly in one position. At such times an excess of débris accumulated along the frontal margin in the form of moraines. Such a deposit occupies the extreme northern portions of Janesville and Center townships and the southwestern corner of Porter township. This belt consists of hummocky knolls of sand and gravel covered with large-sized bowlders of granite, diabase, quartz-porphyry, diorite, and mica and hornblende schists, all derived

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from an area of crystalline rocks in the Lake Superior district. Bowlders of similar character occur less numerously throughout the entire area.

In the extreme northern portion of the area are found a large number of lenticular hills arranged with their longer axes nearly parallel and having a northeasterly and southwesterly trend. The material composing the central core of each of these hills consists of a gravelly gray or drab till which in each case rests upon a floor of limestone or sandstone rock. The central core usually has a veneering of loam, in some cases forming the Janesville silt loam and in others the Edgerton silt loam types, as is also the case with the other till deposits of the region. This gravelly till is found at few other places in the area. It differs markedly from the materials giving rise to the soil types, and seems to indicate beyond question an earlier glaciation correlative with the Illinoisan glaciation farther south, while the greater part of the glacial material comprising the surface of the area belongs to the more recent Wisconsin till sheet. These lenticular hills, called "drumlins," are remnants of the old glaciation carved into their present shape, given their uniform parallel trend, and veneered over by a distinct deposit, through the operation of the ice at a later period.

The consolidated rocks underlying the glacial deposits exert little influence on the surface soils. These rocks consist of thin-bedded, somewhat shaly limestones and of coarse-grained saccharoidal St. Peter's sandstone of Silurian age. The limestones frequently contribute narrow bands of stony soil where the Janesville silt loam has been worn thin through long-continued erosion. The St. Peter's sandstone has contributed largely, both during the period of glaciation and since, to the sand content of some of the types, for instance, the Miami loam. The coarse, rounded quartz grains found in that type are very similar to the round grains of the St. Peter's sandstone. The limestone of this region furnishes some fair quarry stone and has been utilized for burning into quicklime. If properly crushed it might serve as a better material for the surfacing of highways than any other material found in the region. It is abundant and cheap, easily crushed, packs and cements well, and will outwear the gravel used so largely in the roads of the area.

A large part of the silty clay subsoils of several of the types could be used as needed for the manufacture of brick, tile drain, and other terra-cotta articles. This area is well located for manufacture, being about midway between the coal deposits of Illinois and the iron and copper deposits of the Superior region.

SOILS.

Ten soil types are found in the Janesville area. Their location and boundaries are shown on the map, and their chief peculiarities are

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described in the report. The extent of each is shown in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Janesville silt loam	81,344	28.2	Muck	10,368	3.6
Edgerton silt loam	81,216	28.2	Mackinaw gravel	9,024	3.1
Miami loam	51,968	18.0	Janesville loam	6,656	2.3
Meadow	18,112	6.3	Miami black clay loam	1,856	0.7
Afton fine sandy loam	16,256	5.6	Total	288,448	
Hanover sand	11,648	4.0			

JANESVILLE LOAM.

The Janesville loam consists of a surface soil of fine brown loam from 12 to 14 inches in depth. It is underlain to a depth of several feet by a fine, massive, yellow loam of very uniform texture. It is neither markedly clayey nor sandy. The Janesville loam constitutes the principal type found on the Rock Prairie. It occupies both sides of the river near Janesville and attains its greatest development beyond the eastern border of the map. The surface is almost uniformly level, being interrupted only by shallow stream channels of little length or breadth. This type normally grades off along its margins into the Miami loam. Between the two types no sharp boundary exists.

The complete underdrainage of this soil type is insured by the presence beneath its subsoil of thick layers of gravel and sand. No underdrainage has been attempted on the Janesville loam, nor does it seem necessary.

This type has long been valued for its grain-producing capabilities. Under average seasonal conditions the yield of corn is about 60 bushels per acre, that of oats from 45 to 50 bushels, of barley about 40 bushels, and of hay 2 tons to the acre. The average tobacco yield of the Janesville loam is about 1,400 pounds per acre. (See Pl. XXXI.) A first-class quality of binder leaf is secured. With proper fertilization tobacco may be raised several years in succession on the same field. The Janesville loam constituting the open prairie and bordering upon Rock River was one of the first soils selected for settlement by the early pioneers. It has maintained a high degree of fertility from 1835 to the present time.

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The following table gives the mechanical analyses of this type:

Mechanical analyses of Janesville loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7088	3¼ miles N. of Janesville.	Brown loam, 0 to 12 inches.	5.78	0.10	0.48	0.40	0.90	6.10	72.86	18.38
7092	Janesville	Brown loam, 0 to 10 inches.	3.97	.20	1.58	2.08	2.04	5.28	68.14	20.32
7090	.....do	Brown loam, 0 to 18 inches.	2.77	.10	.74	.74	1.12	4.60	70.88	20.88
7093	Subsoil of 7092......	Yellow silty loam, 10 to 36 inches.	.94	.04	1.58	3.46	3.00	6.30	69.82	15.50
7089	Subsoil of 7088......	Yellow silty loam, 12 to 36 inches.	1.49	Tr.	.30	.30	.94	6.84	75.60	15.92
7091	Subsoil of 7090......	Mottled silty clay, 18 to 36 inches.	1.28	.10	.74	.86	1.32	4.96	75.54	16.02

JANESVILLE SILT LOAM.

The Janesville silt loam consists of about 10 inches of mealy chocolate-colored loam that has a deep reddish-brown color when wet. This is underlain by a sticky, reddish-yellow silty clay, with a depth of 30 inches or more. The subsoil normally rests upon gravel or upon the prevalent limestone rock of the region. In Plymouth and Newark townships, of Rock County, small areas of Janesville silt loam differ from the general type in possessing a thickness of only 12 or 14 inches. In these areas there are many small patches where the surface is strewn with broken fragments of shaly limestone. These patches usually lie on the steeper hill slopes and owe their origin to the removal, through erosion, of the greater part of the overlying soil. Throughout the entire area of the Janesville silt loam there are found small hills and hummocks of rounded gravel and of sand, while the steeper slopes are commonly more sandy than the average of the type.

The Janesville silt loam finds its most extensive development in Janesville, Center, Porter, Dunkirk, Pleasant Springs, and Christiana townships. (See Pl. XXX.) It is uniformly rolling or hilly and is thoroughly well drained by many small streams. The Janesville silt loam owes its origin to deposition of glacial material. It rests either upon the consolidated rock or upon glacial gravel, and many erratic bowlders from the Lake Superior region are found over its entire extent.

It is one of the strongest and most fertile soil types of the region, forming the larger portion of the original rolling prairie of southern Wisconsin. It produces, under average seasonal conditions, from 50

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to 60 bushels of corn per acre, from 40 to 50 bushels of oats, about 1½ tons of hay, and 1,200 pounds of tobacco. It is only less desirable than the Janesville loam of the Rock Prairie and constitutes one of the finest soils of the region for general farming. It is too heavy a type for the production of wrapper tobacco, though producing a good quality and large quantity of the binder leaf.

The following mechanical analyses show the texture of this soil:

Mechanical analyses of Janesville silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7074	1½ miles NW. of Stoughton.	Brown silty loam, 0 to 8 inches.	4.87	0.12	0.56	0.56	1.44	6.20	76.98	12.44
7084	5 miles W. of Edgerton.	Brown silty loam, 0 to 6 inches.	3.01	.20	2.44	3.62	7.06	7.26	64.24	14.66
7072	3 miles NE. of Hanover.	Reddish-brown loam, 0 to 12 inches.	4.14	.38	3.70	5.42	7.32	6.66	60.24	16.24
7078	2 miles SW. of Fulton.	Brown loam, 0 to 12 inches.	6.20	.10	.58	.52	1.88	4.16	69.02	23.50
7075	Subsoil of 7074......	Reddish-yellow silty clay, 8 to 36 inches.	1.14	.04	.58	.54	1.60	6.98	79.48	9.94
7079	Subsoil of 7078......	Reddish-yellow silty clay, 12 to 36 inches.	1.38	.42	.88	.68	2.00	6.58	74.16	15.14
7073	Subsoil of 7072......	Loam, 12 to 36 inches.	1.35	.04	1.26	2.58	3.54	8.34	68.22	15.84
7085	Subsoil of 7084......	Silty clay, 6 to 36 inches.	.86	.08	1.66	2.40	2.74	6.10	70.18	16.08

EDGERTON SILT LOAM.

The surface soil of the Edgerton silt loam is composed of about 8 inches of very fine sandy to silty loam. When dry it is ash colored to light gray, and when moist light brown in color. It is underlain to a depth of several feet by a stiff, silty yellow clay subsoil that is uniformly mottled with gray markings. Both soil and subsoil are lighter colored than the Janesville silt loam.

This soil type occupies the hill country in southern Rock and Plymouth townships and throughout Fulton, Albion, Dunkirk, Christiana, and Pleasant Springs townships. It alternates with the Janesville silt loam, forming broad bands across the area.

The Edgerton silt loam is fairly well drained, but requires tile underdrainage for the purpose of furnishing a thorough air circulation to the subsoil as well as to remove excess of rain water. This soil type is also one of the products of the former glaciation of Wisconsin. It

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more nearly approaches typical glacial till than any other soil in the area. It is frequently interrupted by long, narrow ridges and oval, conical hills of gravel and bowlders. Many granite, diabase, and schist erratics are scattered over the surface of this type. Throughout its area are also found large numbers of conical or irregular depressions without outlets, known as kettle holes. These frequently contain water during a part or all of the year.

The Edgerton silt loam, though originally in part forming open prairie, consisted chiefly of oak openings. Even at the present time the greater proportion of the oak timber in the area is found on this soil type. The crop yields on the Edgerton silt loam average from 45 to 50 bushels of corn per acre, about 40 bushels of oats, from 1 to 1½ tons of hay, and from 1,100 to 1,200 pounds of tobacco.

The following mechanical analyses give the texture of the Edgerton silt loam:

Mechanical analyses of Edgerton silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7064	4 miles SW. of Fulton.	Fine gray loam, 0 to 12 inches.	3.10	0.10	1.06	1.08	2.86	8.20	72.80	12.98
7066	3 miles NE. of Stoughton.	Fine loam, 0 to 6 inches.	2.17	.06	.72	.80	2.40	7.84	74.44	13.72
7062	8 miles N. of Janesville.	Fine brown loam, 0 to 6 inches.	2.53	.34	2.12	1.30	2.58	9.72	69.20	14.52
7060	4½ miles SE. of Hanover.	Fine loam, 0 to 12 inches.	3.95	.02	.20	.48	1.20	3.86	79.34	14.62
7067	Subsoil of 7066......	Mottled silty clay, 6 to 36 inches.	.61	.00	.46	.66	1.56	7.22	72.46	16.74
7065	Subsoil of 7064......	Mottled silty clay, 12 to 36 inches.	.64	.00	.58	.40	1.10	5.88	71.44	19.82
7061	Subsoil of 7060......	Yellow clay, 12 to 36 inches.	1.02	.01	.08	.22	.74	3.98	74.86	20.00
7063	Subsoil of 7062......	Yellow clay, 6 to 36 inches.	.61	.20	1.90	1.60	2.46	7.18	59.34	27.20

MIAMI LOAM.

The surface 8 inches of the Miami loam consists of a compact brown loam containing from 15 to 30 per cent of coarse, rounded quartz sand. This sand content varies through moderate limits over single fields. From 8 inches to an average depth of about 18 inches the subsoil consists of a sticky, reddish sandy loam, frequently spoken of locally as "sandy clay." This is uniformly underlain by a deeper subsoil of fine to medium gravel imbedded in a sticky matrix of sand and clay. This soil type is found on the level prairie bordering both

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sides of Rock River, along the Bass Creek Valley from the Rock River past Leyden toward Evansville, over the hills near Center, and similarly upon the hills in the northern part of Beloit Township. Small areas are also found near Orfordville and in the extreme northern portion of Pleasant Springs Township, Dane County.

The surface of the Miami loam is about evenly divided between level prairie land and rolling hill country. In both cases it is well drained. There is not a sufficient amount of clay in the subsoil nor a sufficient depth to the subsoil in the Miami loam to produce large yields in a dry season. It furnishes a warm seed bed and gives early germination for all crops. The average yield of corn on this type is about 40 bushels per acre, that of oats about the same, while hay produces from 1 to 1½ tons. The yield of tobacco is about 1,100 to 1,200 pounds to the acre, and, during the season of 1902 at least, the texture of the leaf raised on this type approaches more nearly to the wrapper grade than any other produced in the region. The ordinary crops suitable for canning purposes may be raised to advantage on the Miami loam.

The following mechanical analyses show the texture of this soil:

Mechanical analyses of Miami loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7096	5¼ miles NW. of Beloit.	Brown sandy loam, 0 to 9 inches.	2.80	0.34	7.90	20.78	27.64	6.50	24.02	12.46
7098	5¼ miles NW. of Janesville.	Brown sandy loam, 0 to 6 inches.	3.34	1.94	15.54	14.40	13.00	4.16	34.30	16.52
7094	3 miles S. of Janesville.	Brown sandy loam, 0 to 10 inches.	3.12	1.54	12.48	15.70	10.58	3.88	38.34	17.10
7095	Subsoil of 7094....	Sandy loam, 10 to 40 inches.	.89	4.50	22.76	24.20	13.80	2.60	20.20	11.52
7097	Subsoil of 7096....	Coarse sandy loam, 9 to 24 inches.	1.51	.40	8.72	19.14	27.04	5.90	24.36	14.34
7099	Subsoil of 7098....	Sticky sandy loam, 6 to 18 inches.	2.08	1.62	15.80	15.74	13.06	2.16	32.28	19.26

AFTON FINE SANDY LOAM.

The surface soil of the Afton fine sandy loam consists of 18 inches of brown loamy sand from medium to fine in texture. It is underlain by a medium to fine yellow sand from 2 to 5 feet in thickness. Locally a small amount of fine gravel is scattered through both soil and subsoil.

Small areas of this type are found near the water level along Rock River and its principal tributaries, but the largest areas of Afton fine

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sandy loam are found between Rock River and Sugar River along the State line. The greater part of this soil type consists of gently sloping or nearly level fields, usually well drained and easy to cultivate.

This soil is probably almost entirely derived from deposits of fine sand laid down by streams issuing from the glacier front during the final retreat of the glacial ice, though some of the smaller areas, especially along Rock River, have been formed from accumulations of sand carried down by rain wash from the Miami loam.

This soil forms the nearest approach of any in the region to the sandy truck soils of the Eastern and Central States. It is more loamy and not so coarse in texture as the typical truck soils. The Afton fine sandy loam produces medium crop yields. Corn yields from 35 to 40 bushels per acre, oats about 35 bushels, hay about 1 ton, and tobacco about 1,100 pounds of good leaf. The weight per acre of tobacco is not as great as upon those soils containing more clay, but the leaf is somewhat thinner and of better texture. This soil is adapted to the production of sugar corn, green peas, tomatoes, and other crops which mature early. It seems the nearest approach to a soil adapted to the production of wrapper tobacco of any type found in the area.

The following mechanical analyses show the texture of this soil type:

Mechanical analyses of Afton fine sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7056	1 mile S. of Afton..	Brown sand, 0 to 12 inches.	1.47	0.20	4.84	28.54	47.40	4.04	8.56	5.74
7054	1½ miles SW. of Dunkirk.	Fine brown sand, 0 to 9 inches.	2.27	.46	7.70	17.44	24.44	4.52	35.76	9.88
7058	4½ miles NW. of Beloit.	Brown loamy sand, 0 to 18 inches.	2.25	.34	5.90	20.34	44.54	5.50	11.84	10.58
7057	Subsoil of 7056.....	Red sand, 12 to 36 inches.	.79	.20	4.48	29.10	48.84	3.74	6.58	6.16
7059	Subsoil of 7058.....	Brownish-red sand, 18 to 38 inches.	.97	.40	5.80	22.08	51.54	4.66	8.38	6.78
7055	Subsoil of 7054.....	Red loamy sand, 9 to 38 inches.	.45	.20	5.38	17.70	33.56	5.56	23.86	13.06

HANOVER SAND.

The Hanover sand consists of a surface 10 inches of grayish-brown sand and fine gravel. This surface soil usually rests upon a subsoil of sticky yellow sand or upon sand and gravel. In some instances it is underlain by sandstone or limestone rock. The surface soil is a medium to fine-grained sand, which is sharp and angular and packs to

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a firm, compact surface. Usually only 10 or 15 per cent of fine gravel is present in the surface soil. The main areas of this soil type are found in Plymouth and Newark townships. Only small areas are found elsewhere. The surface is usually rolling or sloping and the type is well drained throughout the area.

The Hanover sand is largely an accumulation from the wash of the Afton fine sandy loam or the Miami loam. In other cases it has been formed by the complete or partial erosion of the Miami loam, only the subsoil portions of that type remaining.

The crop production of the Hanover sand is below the average of the region. It is too sandy a type to produce large yields except in an extremely wet season. The average yield of corn upon this soil is about 35 bushels per acre, that of oats about 30 bushels, of hay about 1 ton, and of tobacco about 1,000 pounds, except upon newly cleared land, where the yield is greater. The texture of the tobacco raised on this type is good.

This soil type is greatly in need of the addition of more organic matter. For this purpose crops of cowpeas and of clover should be plowed under and the use of stable manure should be increased.

The following mechanical analyses give the texture of the Hanover sand:

Mechanical analyses of Hanover sand.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7069	11 miles NW. of Beloit.	Gray sand, 0 to 16 inches.	1.07	1.52	14.08	26.16	30.12	6.58	14.58	5.38
7068	Hanover	Medium gray sand, 0 to 16 inches.	.87	1.04	12.54	19.54	30.08	6.60	21.54	8.38
7070	1¼ miles S. of Rio.	Brown sand, 0 to 6 inches.	2.06	.34	4.54	10.70	36.40	18.30	20.90	9.58
7071	Subsoil of 7070	Red loamy sand, 6 to 20 inches.	.70	.90	4.24	10.14	34.90	19.00	18.78	11.80

MACKINAW GRAVEL.

The Mackinaw gravel consists of a coarse gravelly soil and subsoil mingled with sandy loam. It is formed by the outcrop of thick gravel bands along the stream courses and by the exposure of gravel knolls and ridges left by the glacial ice over the hills and uplands of the area. Several stony areas and a few rock outcrops have been included in

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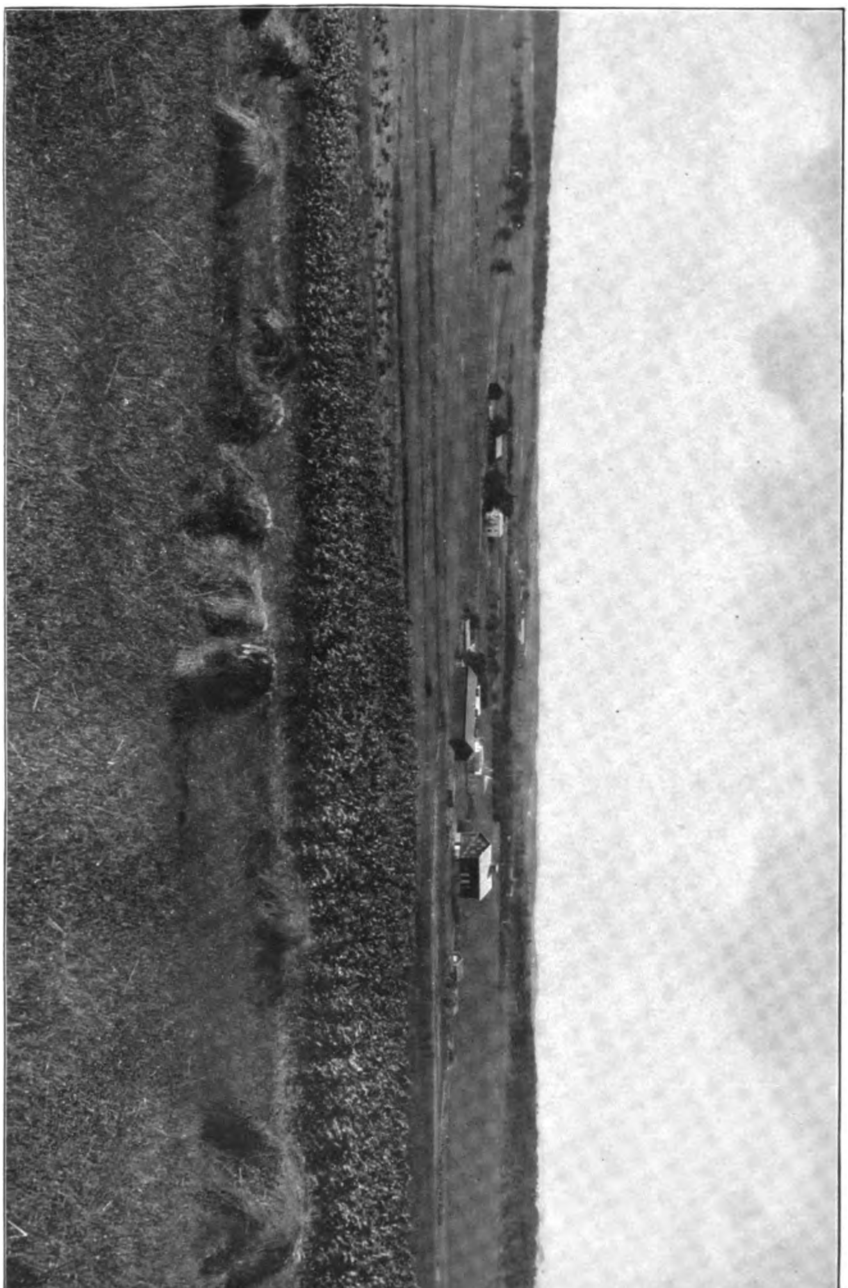

VIEW OF THE JANESVILLE SILT LOAM, JANESVILLE AREA, WISCONSIN, ONE OF THE BEST SOILS OF THE AREA.

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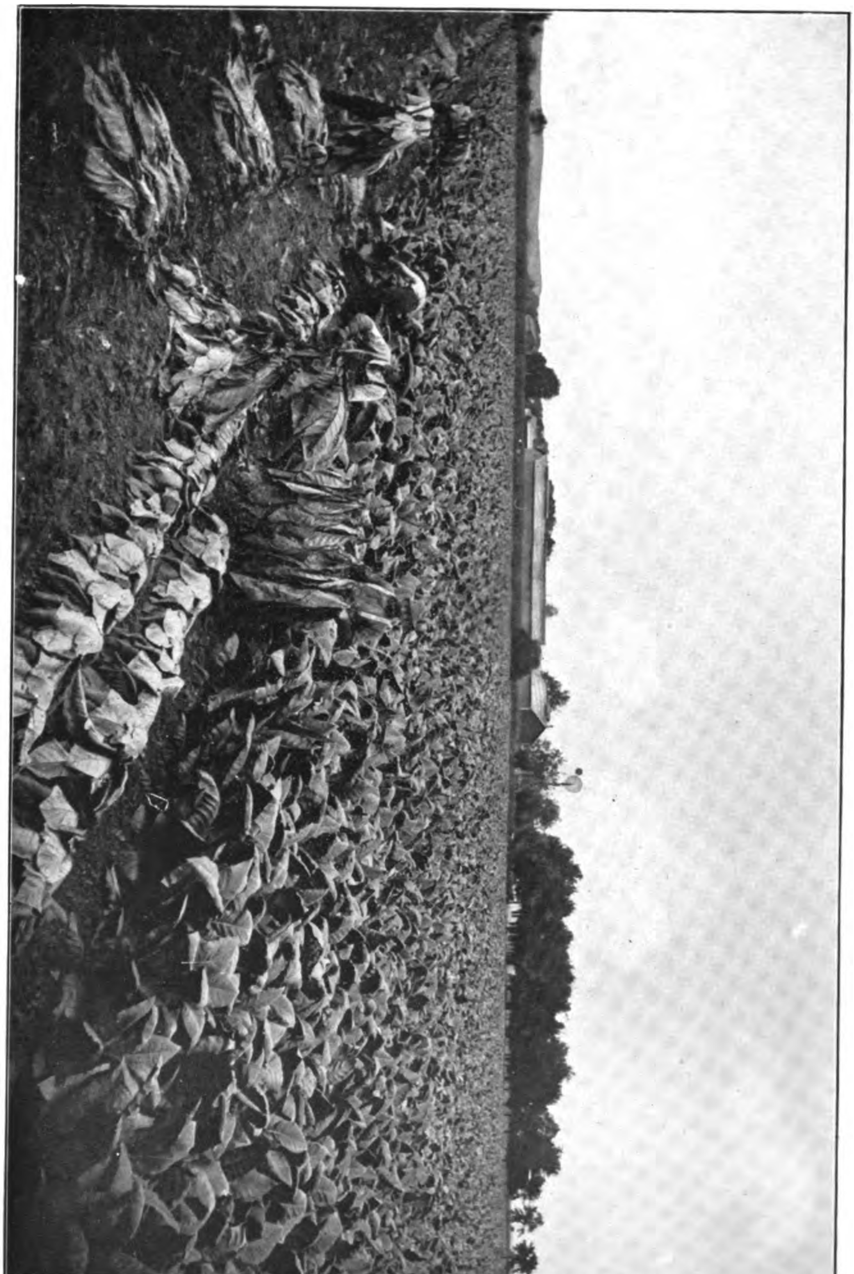

HARVESTING TOBACCO ON THE JANESVILLE LOAM, JANESVILLE AREA, WISCONSIN.

This is one of the important industries of the area.

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this type in the mapping. Many small areas of a few acres in extent have been omitted on the map. They are all easy of detection, forming a conspicuous feature of the landscape. They are usually too small to be represented without exaggeration on a map of the present scale. This soil contains from 35 to 50 per cent of rounded or subangular gravel. The majority of the pebbles are from 1 inch to 3 or 4 inches in diameter, though bowlders of much larger size are of not infrequent occurrence. The fine earth associated with the gravel is usually quite sandy.

The difficulty of cultivating these gravelly and stony areas, both on account of their texture and of the steep slopes usually occupied, has led to the extensive use of the Mackinaw gravel as pasture land. In many instances small groves and clumps of trees have been left standing. This type possesses no especial agricultural value, though grapes do well upon such a soil.

No mechanical analysis has been made of this soil type.

MIAMI BLACK CLAY LOAM.

The surface soil of the Miami black clay loam consists of a sticky black clay loam about 10 inches in depth, locally containing some very fine sand. The surface, when dry, cracks and crumbles into a granular mass of clayey fragments closely resembling the "buckshot" soils of the Mississippi Valley. It is then easily cultivated and possesses all the peculiarities of a friable loam. When thoroughly wet the surface soil packs to a plastic clayey mass. From a depth of 10 to 40 inches the subsoil consists of a sticky yellow or blue clay, somewhat mottled through the presence of hydrated salts of iron.

All of the Miami black clay loam areas are found associated with the Meadow and Muck of the region. Both of these other types, if properly drained, would add extensively to the area of Miami black clay loam. The Miami black clay loam has been formed by the same processes as the Meadow and the Muck, differing from the latter by a much larger proportion of mineral matter to organic matter, and from them both by a somewhat better natural drainage.

The Miami black clay loam is extensively developed throughout the prairie States. Over its entire extent it is preeminently a corn soil, producing from 60 to 90 bushels per acre. In each case when first farmed it was in a thoroughly water-soaked and swampy condition, and was only brought to its present high state of fertility by tile drainage. Extensive areas in Ohio, Indiana, Illinois, and Iowa have been so drained and have amply proved the desirability and profitableness of such reclamation. Hundreds of acres in Wisconsin are awaiting this treatment.

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The following mechanical analyses give the texture of the Miami black clay loam. Comparison should be made with analyses of the same type from Illinois and Ohio.

Mechanical analyses of Miami black clay loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7102	3 miles SW. of Hanover.	Brown loam, 0 to 7 inches.	9.92	1.61	8.50	7.08	13.42	7.88	55.38	6.12
7100	3¼ miles NW. of Albion.	Brown sandy loam, 0 to 10 inches.	4.21	.50	1.68	3.58	14.40	5.54	64.98	8.44
7101	Subsoil of 7100......	Dark clay loam, 10 to 38 inches.	.58	.22	.96	.84	2.56	3.40	76.10	15.88
7103	Subsoil of 7102......	Black clay, 7 to 36 inches.	4.28	.04	.34	.96	2.60	5.06	73.24	17.66

MUCK.

The surface soil of the Muck consists of about 12 inches of organic matter mixed with sand and clay. It is usually underlain by 3 or 4 feet of mottled yellow or blue clay. In other cases the surface soil rests upon a coarse gray quicksand. Nearly all of the Muck areas lie along stream courses, and in many cases are surrounded by meadows. The Muck areas are uniformly flat and are usually covered by bunches of coarse grass or reeds; scattered clumps of willows also occur. The existence of these Muck areas is due entirely to lack of natural drainage. Originally existing as small lakes or ponds, rain wash from the hills has partly filled them up, and water-loving vegetation has encroached around the margins. This mingling of organic and mineral matter has produced a sticky black soil, usually saturated with water.

These areas are best adapted to the production of onions, celery, cabbages, and cucumbers. In many instances further artificial drainage is necessary before any cultivated crop can be raised. For this purpose a broad, open ditch should be excavated by a dredging scow. Laterals should then be laid with tile drains, and the reclaimed land used at first for the production of grass and corn. These crops should be followed by celery, cabbages, and cucumbers. In some instances the quicksand underlying the Muck would have to be avoided in the construction of the main drainage ditch. Its position could be easily determined through the use of an inch and a half soil auger or a long

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iron rod. In other localities lands of similar character, reclaimed at an expense of less than $20 an acre, are now valued at from $100 to $200 an acre. It is to the interest, not only of the owners of these lands, but also of the general community, to have them drained, since the presence of this saturated mass of soil exerts a harmful influence on surrounding cultivated fields. The taxable basis of the county would also be increased.

MEADOW.

The Meadow lands in the Janesville area consist of low, flat, poorly drained areas lying along stream courses, near the margins of lakes, or, in some cases, in extensive hollows which once formed lakes, but which have since been naturally drained and filled. The texture of the soils found in these localities varies considerably. It usually consists of wash from higher-lying lands, mingled with considerable organic matter. A lack of adequate natural drainage is a common characteristic of all the meadows.

At the present time they are furnishing large quantities of rather coarse marsh hay, and after the cutting of the hay crop are used for pasturing stock. They are particularly valuable for this purpose, since the excess of moisture which prevents cultivation maintains a luxuriant growth of grass at a time when the upland pastures begin to fail.

In many cases the areas mapped as Meadow could be reclaimed through the use of tile drain, and would form excellent corn ground. A very moderate slope will give sufficient fall, and the total expense for the drainage should not exceed $12 or $15 an acre. In case of the larger Meadow areas a single large open ditch with tiled laterals would form the best drainage system. In most instances a small amount of drainage would throw these Meadow areas into the same condition as adjoining soil types. For this reason some of the narrower strips and small isolated patches have been omitted from the map.

TOBACCO.

The cultivation of tobacco in the Wisconsin area was begun in 1858 by growers who introduced the crop from the East. The Connecticut type was first raised, but it has been superseded by the Spanish binder tobacco derived from West Indian seed. The crop was first raised in small garden plots and fields. It has since increased in importance until, in 1899, 33,830 acres of tobacco were raised in the State. The area of production has spread from a few farms in Rock and Dane counties until it comprises about all of the south central portion of the State. In 1899 over 45,500,000 pounds were produced.

The Wisconsin tobacco is chiefly of the binder type, about 80 per cent of the crop belonging to this class. About 5 per cent is of

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proper texture for wrappers, while the remaining 15 per cent, consisting chiefly of ground leaves, broken stock, and fleshy upper leaves, constitutes filler. The characteristics of the Wisconsin binder leaf are as follows: It must be of a good burning quality with a white ash; it must be tough and elastic, with medium sized veins; the lighter colors are preferable, but this is not so important as is the case with the wrapper leaf; a clear, glossy face is desirable but not essential. It has been noticed with the Wisconsin leaf that it loses its gloss to a certain extent after being wrapped on the cigar. The average size of the Wisconsin leaf is from 18 to 20 inches in length and from 10 to 14 inches in breadth. The color is a medium shade of cinnamon brown. The Wisconsin leaf averages a yield of about 1,300 pounds per acre for the area. This yield is frequently exceeded. The average price to the farmer is about 6 or 7 cents a pound. The crop is usually sold from the barn and is quoted for binder and filler grades; for instance, a crop may be sold at 8 and 2 cents a pound, the prices being quoted for the two grades. The average cost of production is said to be 3 to 3½ cents per pound. Much of the Wisconsin tobacco is handled very roughly during harvesting and curing, and some improvement might be made in this respect, although the low price per pound would not justify any great refinement in method. (See Pl. XXXII.)

The method of cultivation and handling of the Wisconsin crop is not sufficiently different from that of other tobacco districts to require a special description. The curing in this climate takes from six weeks to four or five months. The latter time is required when the crop is frozen before being completely cured in the fall. After curing the tobacco is sorted at the shed into binder and filler grades. The buyer usually views the crop in the sheds and buys according to his estimates. Recently competition among buyers has led to some selling from field estimates. The tobacco, after being removed to the warehouses, is sized to 1½-inch limits in length of leaf. It is then packed in large bulks containing about 5,000 pounds, where it is allowed to remain for about fifteen days. During this time fermentation is begun and the tobacco goes beyond the danger of black rot. It is then packed in cases of about 350 pounds weight and the fermentation completed.

The tobacco fields of Wisconsin are fertilized chiefly with barnyard manure, and nearly every tobacco farm is also a stock or dairy farm. In spite of the liberal use of this fertilizer it is noticed that the fields located on the newer lands produce a larger quantity and better quality of tobacco than those of the older fields which have been liberally fertilized with stable manure. The use of special commercial fertilizers is scarcely known in the area, only $6,000 worth of this class being used on the 4,000 farms of Rock County in 1899. In order to restore the older tobacco lands to some measure of their former productiveness it will be necessary to employ nitrogen and potash fertilizers.

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Of these cotton-seed meal has been most successfully used in other areas as a source of nitrogen and some form of potash as a source of that element. The introduction of the sugar-beet industry into the area, foreshadowed by initial experimental crops, would be of service to the tobacco growers, since the cheapest vegetable potash supply is derived from the burned refuse of the sugar-beet factories. The amount of cotton-seed meal necessary to produce the best results makes it a very expensive fertilizer. Some growers use as much as 1 ton per acre, costing them $30 to $35 for this single item. This expenditure would probably not be justified with the binder type of leaf, but carefully conducted experiments should soon develop the best practice regarding this and other special fertilizers.

For several years the most progressive tobacco merchants in Wisconsin have felt that the necessities of a balanced tobacco trade required the production of some form of wrapper tobacco within the limits of the State. With the initiation of the shade-grown Sumatra leaf in the Connecticut Valley some of them became more than ever desirous of introducing this particular class of tobacco into the Wisconsin area. In the season of 1902 Messrs. S. B. Heddles and F. S. Baines, at their own expense, built shade areas, the former inclosing about 2 acres and the latter nearly 1 acre under canvas. The framework of both tents was better constructed than the average of the Connecticut tents, and both gentlemen report the cost of their equipment as considerably higher than that prevailing in New England. Both experiments were undertaken on the Janesville loam, Mr. Heddles's tent being located near its margin and Mr. Baines's upon Mr. Snell's farm, well within the limits of the type. This soil is considerably more clayey than any upon which Sumatra tobacco has been grown successfully in New England. In addition, the season of 1902 was unfavorable to such an experiment, being marked by excessive rainfall during the growing season and by an average temperature considerably below the normal. In spite of these unfavorable conditions both crops appeared well at the time of harvesting, showing a luxuriant growth reaching nearly or quite to the tops of the tents and yielding a large amount of tobacco to the acre. As neither crop has been cured as yet it is impossible to state that the experiments have met with complete success. Certainly much has already been learned and thus far the experiment may be called successful. Further trials will be made by the gentlemen interested.

In selecting new areas for experiments in the production of wrapper tobacco the experience of other areas would indicate that the most sandy types found in the Janesville area are more liable to bring success than the heavier soils at present preferred for the binder tobacco. Thus no competition occurs between the two grades, either in production or consumption, and each serves to supplement the other in the American tobacco trade.

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AGRICULTURAL CONDITIONS.

The general appearance of the Janesville area is that of a well-conducted, successful agricultural community in which the agriculture is closely linked and prospers with the flourishing manufacturing industries of the cities of the region. Beloit and Janesville, cities of more than 10,000 population, are each the seat of considerable manufacturing. In both the production of agricultural implements holds a prominent place. Edgerton and Stoughton likewise are considerable manufacturing towns. Janesville, Edgerton, and Stoughton are prominent centers of the Wisconsin binder-leaf tobacco trade. The many warehouses in each of the cities employ a large number of hands in the sorting, grading, and packing of the crop. Tobacco from outlying districts is brought to these centers for warehouse handling. In addition to the above interests these towns manufacture furniture, cloth, clothing, and various other articles of commerce. Large quantities of tobacco are also manufactured into cigars within the district.

The agricultural lands of Wisconsin are all laid out according to the section and township surveys of the United States General Land Office. The land was originally occupied by the earliest pioneers through a system of squatter rights generally accepted by the pioneers themselves. After the completion of the original Government survey the pioneer occupants secured good Government titles through purchase from the Land Office. The first claims have long since been divided and subdivided until at the present time Rock County, with a total area of 720 square miles, comprises 3,829 farms, of which 3,762 are improved with buildings. The total value of farms for the county amounts to over $20,000,000. The additional value of the farm buildings amounts to over $5,800,000. Throughout the county the average size of the farm is 112 acres, slightly less than the average for the State. The average value of the farms is about $5,250 each, with improvements other than buildings, while the average value of the buildings on farms thus improved is $1,550. The average value of farm products not fed to cattle amounts to $1,137 per farm annually. This represents a gross income of 17 per cent on the investment, without counting the value of live stock maintained on the farm. In Dane County the average size of the farms is 115 acres and the other averages range only slightly less than in Rock County. The portions of these two counties included in the present area are very fairly represented by statistics of the counties as a whole.

The greater proportion of the farms in the area are operated directly by their owners or through managers who are paid a fixed salary. Over 80 per cent of the farms are thus operated. The remaining farms are operated in about equal numbers by money tenants and share tenants. The farms are maintained in much better condition than in regions where share farming is more prevalent.

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The buildings are substantial, neat, and well painted. The fences, chiefly of wire, are carefully maintained. Nearly every farm is provided with windmill and tanks, supplying water for both household and farm use. The greater number of the farms in the region, in addition to a comfortable dwelling house of wood, brick, or stone, are provided with a small stock barn with hayloft, with corncribs and outbuildings for minor stock, and with one or more large tobacco sheds. When not in use for hanging tobacco, other farm products and the farm machinery are stored in the tobacco sheds. The ruinous practice of leaving farm machinery exposed to the weather is noticeably absent in this area.

The majority of the farms in the Janesville area are devoted to general agriculture as distinguished from specialized branches, such as trucking and market gardening. The greater number maintain small herds of dairy cows and some beef stock. A few hogs and various kinds of poultry are usually kept, chiefly for the needs of the farm. Many flocks of sheep are also found in the area. The principal crops raised are field corn, sugar corn, oats, rye, barley, sorghum—usually in small patches—potatoes, and tobacco. Beets and turnips are raised to a limited extent, while the production of cabbages and cucumbers, which with the sugar corn are sold to the canning factories, is steadily increasing. Hay is one of the chief crops, while a considerable area is devoted to pasturage. In addition to the tame grass of the upland fields, considerable marsh grass is cut from the lowland swamps and meadows. Two crops of hay are frequently cut in a year and considerable amounts of timothy and clover seed are thrashed annually. The dairying industry is constantly increasing in importance throughout the region. Formerly the butter was manufactured as a farm dairy product. While this practice still continues upon many farms, the greater part of the milk is sent to creameries, many of which are located in the area. Very little cheese is manufactured. A large proportion of the butter finds a ready local market. The special industry of tobacco raising is described in a separate chapter.

On account of the small average size of the farms, and particularly because they are chiefly operated by their owners, the labor of field operations is principally performed by the farmer or by members of his family. The average expenditure for farm labor in Rock County amounts to only $110 per year for each farm. A considerable proportion of this is paid out during the harvesting of hay, grain, and especially the tobacco crop. During the balance of the year very few extra hands are hired. In the production of the tobacco crop a somewhat novel variation on the share system has been originated. The land owner or the renter possessing the stock, land, implements, and building for handling a crop of tobacco plants as much as he himself can handle without hiring additional labor. He then prepares ground for an additional tobacco area which is handled both during

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the growing season, during harvesting, and curing by "sharemen," who give him one-third or one-half of the crop for the use of the land and the labor involved in its preparation.

All of the soil types found within this area are used for general farming purposes, and any recognition of the special adaptability of any one soil type to a particular crop is limited to a more or less defined conception of the amount of the crop which can be raised upon different farms. For instance, it is recognized that the Janesville loam of the Rock Prairie, the Janesville silt loam of the upland prairie, and the Edgerton silt loam of the "oak openings" will produce larger crops of hay, grain, and tobacco than the more sandy soils such as the Miami loam, the Afton fine sandy loam, and the Hanover sand. It is also recognized that the tobacco leaf raised on the sandier soils is frequently thinner and of finer texture than that raised on the more clayey soils, but since the yield per acre is considerably greater on the heavier they are considered the best tobacco soils of the area. This is due to the fact that only one variety of tobacco, the binder leaf, is advantageously grown in Wisconsin. Consequently the chief aim is to secure the largest leaf and the greatest possible weight per acre.

Of the ten soil types found in the Janesville area the Janesville loam will produce the largest yields of hay, grain, and binder tobacco. It compares favorably with the typical corn soils of the prairie States, approaching most nearly the Delavan silt loam of Tazewell County, Ill. The Janesville loam is the most desirable general farming soil of the area, not only on account of its superior fertility and admirable physical texture, but also on account of its position near the largest cities, its excellent natural underdrainage, and its nearly level surface configuration.

The Janesville silt loam is second only to the Janesville loam as a general farming type. In fertility and physical texture they are very nearly equal, though the Janesville silt loam does not possess as great a depth either of surface soil or of subsoil as the Janesville loam. Its surface is also much more rolling and therefore subject to greater wash from heavy rains. Its yields of hay, grain, and tobacco are proportionately slightly smaller than those of the Janesville loam, and a greater proportion of the former than the latter type is devoted to pasture land. It thus becomes one of the chief stock and dairy types of the area. It is usually well handled, productive, and above the average value of farm lands.

The Edgerton silt loam is not naturally as fertile nor of as good physical texture as either of the preceding types. In addition its surface is more rolling, more subject to wash, and more frequently interrupted by small patches of bowlders or gravel. It is thus more difficult to till and harder to retain in its best state of cultivation. It furnishes the greater proportion of the pasture and grass lands of the

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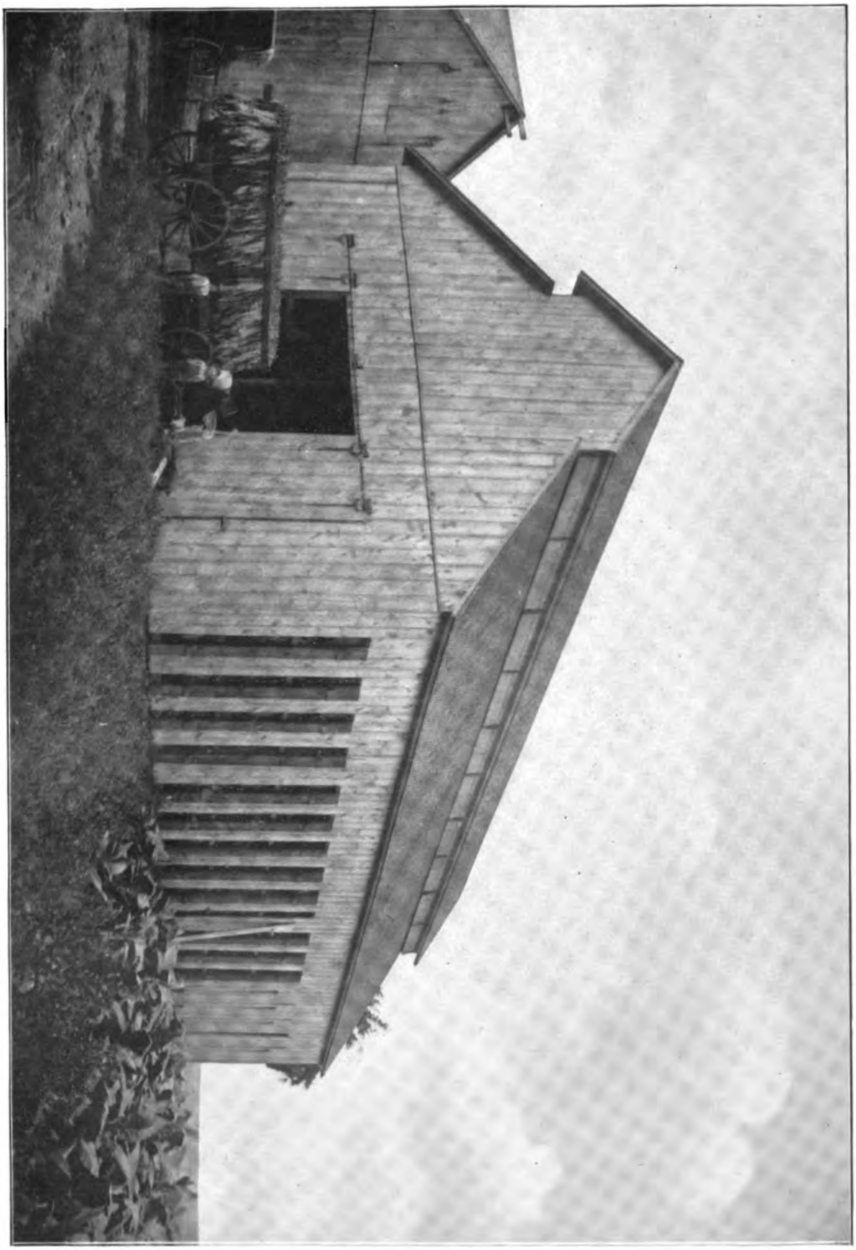

THE TYPE OF TOBACCO BARN USED IN THE JANESVILLE AREA, WISCONSIN.

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area. Allowing for variations in the ability of the producers, the weight of tobacco per acre is less and the size of leaf smaller as raised on the Edgerton silt loam than on either of the preceding types. The productive ability of this type of soil, the certainty of producing a crop, and the ease of tillage could all be materially increased by the expenditure of about $10 per acre on tile drainage, not to reduce the water supply in the subsoil but to institute a more thorough circulation of the soil solutions and the soil atmosphere. In addition to this a suitable crop rotation should be worked out through experiments by the farmers themselves or under the direction of their State agricultural experiment station. To summarize: The chief need of this type is a better circulation in the subsoil and more organic matter in the surface soil.

The above types constitute a group of general farming soils, reasonably distinct from the other soils of the region.

The Miami loam, while of medium value for general farming, is rather light and possesses too shallow a subsoil to compare favorably with the three types already described. It possesses a greater value than any of them for certain special crops used in the canning industry. For the production of sugar corn, of green peas, of tomatoes, etc., it is as well fitted as any soil in the region. Cantaloupes, watermelons, strawberries, and other small fruits could be raised to advantage. Thus the Miami loam occupies an intermediate position between the general farming soils and the truck soils, and is best described as a market-garden soil. The steady growth in population of the manufacturing cities of this region will increase the requirements for market-garden crops, to the advantage of this type of soil.

The Afton fine sandy loam, though not as coarse in texture as the typical truck soils of the Eastern and Southeastern States, approaches more nearly to them than any other type found in the area. It is capable of bringing truck crops to rather early maturity and should supplement the Miami loam, crops on which would mature still later. It likewise approaches the nearest to a type suited for producing wrapper leaf tobacco than any other soil in the area, though falling considerably short of an ideal soil for that purpose.

The Hanover sand, owing to its shallowness and frequently unfavorable location on steep slopes, is not as desirable for any agricultural purpose as the foregoing soils. Under favorable conditions of abundant rainfall fair crops of corn, rye, and tobacco may be produced. The soil is adversely affected by drought to a greater extent than any other in the area.

The Mackinaw gravel, where occurring in areas of more than 1 or 2 acres in extent, is not suited to farming operations. This is so generally recognized that the greater proportion of it is included within pasture lands. It is quite often forested.

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The Miami black clay loam exists in only a few small scattered areas. It is a preeminently fertile corn soil and if more largely developed would be one of the most important types of the region.

The undrained meadows and marshes should be reclaimed to form highly productive fields, especially adapted in the case of the Muck to the growing of celery, cabbages, and cucumbers.

The agriculture of this area is thus capable of much greater specialization than it has yet attained, though the prosperous condition of the farmers at the present time is apt to delay rather than accelerate this phase of development. Fully 85 per cent of the area already consists of well-improved farms, and the future growth of agriculture in the region thus depends more upon specialization in cropping than on extension of the area farmed.

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SOIL SURVEY OF THE DUBUQUE AREA, IOWA.

By ELMER O. FIPPIN.

LOCATION AND BOUNDARIES OF THE AREA.

The Dubuque area includes 440 square miles, or 281,664 acres, and is situated in east central Iowa, the Mississippi River flowing through the northeast corner. A small part of it lies across the river, in the State of Illinois. To give its boundaries more exactly, it is a 15 by 30 minute sheet extending from longitude 90° 30′ to 91° west from Greenwich and from latitude 42° 15′ to 42° 30′ north. Parts of

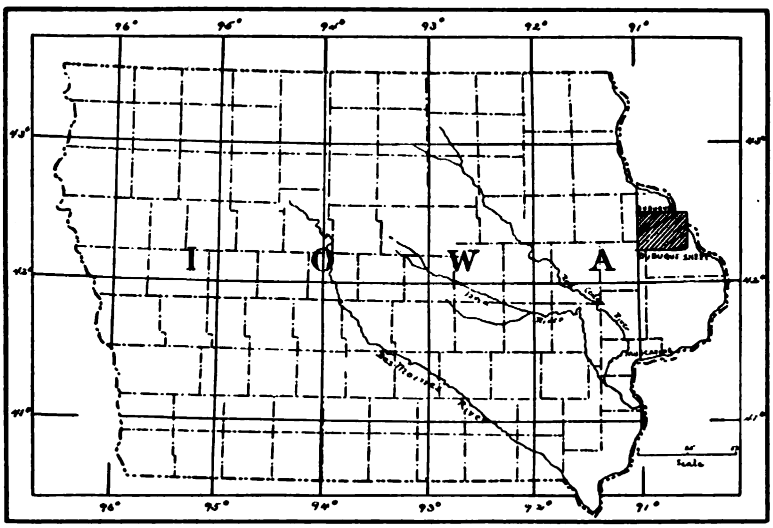

FIG. 15.—Sketch map showing area surveyed in Iowa.

Dubuque, Jackson, and Jones counties, Iowa, and Jo Daviess County, Ill., are included in the area. The largest city is Dubuque, situated on the Mississippi River, and the other important towns are Farley and Cascade, in the western part of the sheet. A half dozen villages are scattered through the area at convenient centers for local trade, and a number of smaller hamlets and crossroad post-offices lie within the area. (See fig. 15.)

The center of trade is Dubuque, a city of nearly 40,000 inhabitants, which, besides being an important railroad center between the East and the Northwest, has in the Mississippi River excellent water communication with many large cities both North and South.

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HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The earliest commercial interest of the area surveyed lay in mining the deposits of lead that occur in the prevalent Galena limestone formation. Julien Dubuque, after whom was named the city of Dubuque, founded in 1825, was the first to mine the deposits in a commercial way. His operations covered the period from 1780 to 1810. Permanent mining operations were begun, about the time of the founding of Dubuque, by pioneers coming from Galena, Ill. As late as 1852 the Upper Mississippi mines yielded 10 per cent of the world's supply of lead and 78 per cent of the production of the United States.

The chance of quickly winning wealth by a rich strike in lead distracted interest from agricultural pursuits, and hence during the twenty years following settlement the development of agriculture in the vicinity of Dubuque was slow.

In its original condition part of the area surveyed was timbered and part was covered by only a scattered growth of hazel bush and other kinds of shrubs. The more broken lands along the Mississippi River, together with fringes along the streams, were occupied by forests of white, black, and bur oak. Maple, basswood, hickory, elm, and poplar also occurred. As the timber growth was largely oak, the term "oak openings" was applied to large areas. In the area above or west of the Niagara escarpment, comprising the rolling prairies, there was no timber, except here and there an occasional tree and a narrow fringe of trees along the streams. Here grew coarse prairie grasses, while large hazel brush extended for a considerable distance out from the timber, as its forerunner. Why there should have been such vast areas without timber covering is a question still awaiting a satisfactory explanation. There is apparently no difference in the soils sufficient to account for such a difference of vegetation. One cause sometimes suggested as possible is the prairie fire, and this theory has much to commend it to further careful consideration.

The first agricultural settlement began in 1830 on the prairie lands, which were easily cleared and quickly brought under the plow. By 1850 practically all such land had been reclaimed, and the timbered lands were being rapidly taken up. The open character of much of the forest made the clearing comparatively easy. The hilly lands along the Mississippi River are said to have been the last to be brought under cultivation. Within the last forty years the local demand for produce has led to the careful tillage of every available slope in the vicinity of Dubuque.

The freshly turned prairie and the newly cleared slopes were very fertile, and all crops yielded in abundance. At that time the leading crop was spring wheat, the yields ranging from 20 to 35 or 40 bushels

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per acre. Corn and hay were grown, but only in limited amounts for local consumption. Live stock, outside of draft animals, were few, and hence the demand for forage was small.

There are several reasons why wheat was the leading crop in those days. The fertile soil yielded generously, the grain formed the principal bread crop, it stood shipment well by water—the Mississippi River being the one connection with the large cities of the East and with foreign ports—and prices were good. Had corn been produced it would have had a more limited outside market, while as feed for live stock the demand would have been light, live stock being raised only for local consumption.

Wheat continued to be the principal crop until about 1875, when it began to give place more and more to corn and hay, which were fed to live stock. From that time to the present the chief products of the farms of the area, in common with eastern Iowa generally, have been cattle and hogs, with a few sheep. There is more than one reason for the transition. The continual growing of wheat on the same land was reducing its fertility, and hence the yield, and the advent of railroads—the present Illinois Central line in 1867 and the Chicago and Northwestern a few years later—opened the way to the shipment of live stock and corn to the East. Added to these forces, and probably stronger than they at the time, were the serious ravages of the chinch bug, which for several years in succession not only destroyed whole fields of wheat, but entered the corn fields after the wheat harvest and did much damage to that crop. When wheat growing had once been discarded for forage crops, live-stock raising and dairying were inaugurated, and the substitution was found to be so much more satisfactory that it continued without interruption, and for the decade from 1890 to 1900 the average yearly production of wheat was comparatively insignificant. Within the last two or three years small trials of wheat have been made with such success that the production of spring wheat bids fair to again assume a prominent place in the crop rotation.

Barley is another crop that formerly received much more attention than at present. Twenty years ago a large acreage was planted, producing from 25 to 35 bushels per acre, and there was a strong demand at good prices. The demand seems to have been curtailed and the acreage has greatly decreased, barley being grown now mainly for feed.

In the live-stock industry the tendency has been from beef production to dairying, the butter being manufactured in factories. This change has come within the last fifteen years. The general features of the country, its surface configuration, and the character of the soil make the production of live stock and dairying most practicable and profitable. The hilly character of the surface in many parts, the

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stony slopes, and the serious damage that may arise from erosion when such areas are kept in cultivated crops are conducive to a large acreage of grass and pasture land, and hence no radical changes in the general system of agriculture of the area are likely to take place. This last statement is not to be understood as excluding modifications in the methods of agricultural practice, which will be considered later in this report.

CLIMATE.

The mean annual temperature for the Dubuque area is about 46° F., and the mean annual precipitation is between 30 and 36 inches.

The following table gives the figures of normal temperature and precipitation at two of the Weather Bureau stations, Dubuque and Delaware, in detail by months:

Normal monthly and annual temperature and precipitation.

Month.	Temperature.		Precipitation.	
	Dubuque.	Delaware.	Dubuque.	Delaware.
	°F.	°F.	Inches.	Inches.
January	17.7	14.3	1.68	1.22
February	22.6	18.1	1.46	.78
March	32.8	30.9	2.27	1.81
April	48.6	46.7	2.79	3.38
May	59.9	57.9	3.99	3.82
June	69.4	68.7	5.20	4.28
July	74.2	71.6	4.28	3.30
August	72.0	68.8	3.15	2.88
September	63.0	61.8	4.09	3.36
October	50.9	46.5	2.71	2.28
November	35.0	29.5	2.10	1.76
December	25.4	21.4	1.81	1.52
Year	47.6	44.6	35.53	30.39

The annual precipitation is thus about 33 inches, and of this amount nearly five-eighths fall during the growing season, which is a very satisfactory arrangement of the distribution. However, periods of more or less severe drought occur from year to year.

Since the beginning of settlement there have been changes in the water supply of the area so marked that they have come under the observation of every old settler. The region was once famous for the number and large size of its springs of water and perpetually flowing brooks, but at the present time very few springs are to be found, the flow of the largest ones is very much reduced, and the majority of the small streams are without water during a large part of the year.

The records kept at Delaware show killing frost in the spring as late as May 31, but the average date, taking the records of the last

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eight years as a basis, is May 2. The earliest frost in fall of sufficient severity to kill tender vegetation occurs usually about October 2. There are, thus, one hundred and fifty-three days in the growing season around Delaware. Near Dubuque the average length of the growing season is one hundred and sixty-seven days, extending from the average killing-frost date of spring, April 19, to that of fall, October 3. The figures given for these two stations may be taken as indicating average conditions in the area at large.

PHYSIOGRAPHY AND GEOLOGY.

The surface of the Dubuque area is generally rolling and hilly. Along the Mississippi River, which flows across the northeastern corner, separating the Iowa part of the area from that in Illinois, the topography is rougher and still more broken. The elevation ranges from 600 feet along the river to 1,200 feet on the divide, some 10 miles to the west. This divide, which is in fact a watershed between the two sets of streams that drain the area, extends from Farley to Epworth and thence in a southeast line through Lamotte. Throughout its whole extent it maintains an elevation of not less than 1,000 feet, and for the greater part of the distance reaches 1,100 feet. An elevation of 1,200 feet is reached in three small knolls in the southeastern corner of Table Mound Township. The entire drainage finds its way into the Mississippi River. The streams east of the divide are short and flow directly into the Mississippi, while those on the west reach it indirectly through the Maquoketa River and its tributary, the North Fork, which cuts across the southwest corner of the area at Cascade. The streams west of the divide are much longer and generally have a less slope.

The area was originally a plateau composed of limestone and shale, but out of the once level surface the streams have carved a complete system of channels of the dendric type. The streams divide and subdivide until they end in a thousand small brooks and rills that find their source for the most part in the headlands bordering the main divide or watershed. As a result of the work of the many streams the whole country is now a series of rounded ridges with a long swell, as in the region of shale, or with precipitous slope where limestone is the basal material. The general convex outline of the ridges and valleys shows that the process of eroding the country down to base level is scarcely half completed, notwithstanding that hundreds of feet of material have been carried away.

The physiography of the area may be described under two general heads—the driftless area, occupying the eastern third of the area surveyed, and the area of glacial débris lying above or west of the main

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divide. The former of these includes the Mississippi River and those streams that flow directly into it, and affords an excellent example of the kind of surface this whole northern country would now present had there been no ice invasion to plane down the eminences and fill in the depressions. It is characterized by bold outlines and rugged cliffs. The two series of limestones and the intervening stratum of shale have been cut through, the streams occupying narrow, rock-bound gorges where they pass through the limestone and comparatively deep channels where they pass through shale. The gorge of the Mississippi River, extending in a southeast direction, has an average width of 1½ miles and is bounded on each side by rocky walls, ranging in height from 250 feet at Gate City, where they approach nearest each other, to 60 feet at other points along the course. Where inflowing side streams have cut through them these walls follow the course of the streams, forming precipitous slopes simulating canyons. The varying hardness of the rock has caused it to be eroded unevenly, and the more obdurate parts have been chiseled into giant columns that form, with their rugged outline and their honeycombed and weather-beaten surfaces universally set in a mass of vegetation, a striking part of the scenery of the country. Instances of this kind abound in all the region around Dubuque, and in passing up or down the stream courses one pleasing vista succeeds another in rapid succession. The formation occurs alike in the upper and lower limestone regions, only differing in the extent to which erosion has progressed. The softer parts of the limestone form more gentle and receding slopes, while the shale gives very long, rounded slopes with a graceful swell.

The bottoms of the gorges are occupied by a ribbon of flat, level land, through which the streams wind in narrow channels, usually with almost vertical walls. The larger streams have a more meandering character and the materials composing these bottoms are less uniform. The main stream of the Mississippi River flows through flat bottom lands, through which bayous and side channels have cut their way, forming a number of islands of varying sizes. These islands are low, flat, and subject to occasional overflow. Near Dubuque considerable island areas are cultivated, but below the city they are covered with timber. The other large streams of this part of the area are Catfish Creek and its tributaries, the Tête de Mort River, and the headwaters of the Little Maquoketa, the valleys of all which have the character of those of the small streams in general. The channels are seldom divided, and overflows of the bottom lands occur only at long intervals.

Aside from the lower stream gorges, a distinct phase of the topography of this region is the outcropping edge of the magnesia limestone, whose proper place in the geological scale will be noted later in this report. This outcrop, known as the Niagara escarpment,

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extends over the country as a sinuous line of hills with steep slopes ranging in height from 60 to 150 feet. On the large inner stream divides it extends far out toward the Mississippi River, while along the streams it recedes, forming a steep rim to the valleys and finally embracing their sources. The sudden rise of these limestone hills from the long slope of the shale is most noticeable. Table Mound, in Table Mound Township, as well as numerous other hills that are less marked, are the extensions of this Niagara limestone formation. The Niagara escarpment is between 6 and 10 miles from the river at Dubuque and approaches to within half a mile of the river on the east central border of the area. On the eastern side of the Mississippi River this escarpment does not occur in the area, the Niagara limestone formation being absent. The other topographic features are identical with those on the Illinois side of the river.

The western two-thirds of the area is more level than the eastern part and is sometimes spoken of as the rolling prairie. It is far from being level, but the slopes are more gentle and of a less height. The general slope is to the southwest. The larger streams are John, Whitewater, Prairie, and other creeks, besides a part of the North Fork Maquoketa River. These streams belong to the dendric or ramifying type, but have cut less deep into the limestone, and besides, the area has been overrun by ice, which tended to plane down the ridges and fill in the depressions. The most broken area is along the North Fork Maquoketa in the region south of Washington Mills. In the western 6-mile tier of sections there are three distinct lobes which have been twice overrun by the glaciers. Here the outlines are distinctly more modified than in the other portions of this western area. The hills present the appearance of having been rubbed or plowed down, and there are no sharp slopes. The lobes have a southwest direction, entering the area at Farley, in northern Whitewater Township, and at Cascade. The stream gorges and the bottom lands are of the same character as those in the eastern third of the area.

From a geological point of view the area under consideration is one of the most interesting in the country, because of the variety of its materials, the character of their exposures, and the topography resulting from their relative positions. The lowest formation exposed to view in the area is the Galena limestone, which forms the bluffs fringing the Mississippi River and its tributaries. It is 250 feet thick at Dubuque. It is a buff or gray-colored stone, strongly magnesian, somewhat cherty, and the source of the lead mined at Dubuque. Above the Galena formation occur the Maquoketa shales. They are blue or drab in color and very heavy and impervious. To their easy weathering is due the long, rounded slopes between the lower and

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upper limestones which are so noticeable in the vicinity of Dubuque. When weathered out the shale forms a most intractable blue clay, so stiff that it would seem impossible to utilize it for agricultural purposes were it on the surface.

The third formation is the Niagara limestone. It is a creamy to gray colored stone, very cherty and highly dolomitic. Its thickness varies from 30 to 350 feet and its exposure ranges from an elevation of 800 to 1,200 feet above tide.

The residual material from both the limestone formations is a very stiff, sticky, dark red clay filled with chert fragments. The color is due to the high percentage of iron compounds which the rock contains. It nowhere forms a considerable portion of the surface covering.

In general, the area over which the Niagara limestone is the highest indurated formation has been subjected to glacial action. Two distinct advances of the ice are discernible, between the occurrence of which countless centuries elapsed. The first of these was the Kansian glacier, which spread over the country as far as the Niagara escarpment. The border of this ice sheet waves back and forth over several miles of territory, a distinct morainic deposit occurring throughout much of its extent. The materials composing the drift are sands, clays, and bowlders in varying proportions.

Of the strata that have been mentioned thus far none enter into the formation of the present soil covering of the area. The limestones might seem to be exceptions to this, but they are represented only by stony outcrops, the fine material mixed with these rock fragments being of another origin. Only glimpses of the other formations are had occasionally in gullies and cuts.

The second or Iowa invasion of the ice was the source of the present soils. The drift from this glacier is only found in the western fourth of the area, where it occurs as the elongated lobes of small hills, the first entering at Farley and reaching to Epworth, the second entering in northern Whitewater Township and reaching to Bernard, and the third following the North Fork of Maquoketa River and one of its tributaries from Cascade to a point a few miles south of Garry Owen. All three have a southeast direction. They are mainly indicated by a series of sandy loams, with occasional large and small erratic bowlders scattered about on the surface. Reaching out from the border of the Iowa drift is a continuous sheet of finely divided and homogeneous material lying unconformably over the formations mentioned. It is largely a silt, and contains no particles coarser than fine sand. Because of certain peculiarities it has been termed loess, and is correlated with vast areas of the same material that extend through the Mississippi Valley from southern Louisiana and Mississippi to Canada. This is the material from which 90 per cent of the soils of the area is derived.

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The geological formations that are exposed and their position in the scale and the soils derived from them are given in the following table:

Time.	Era.	Period.	Formation.	Soil.
Cenozoic	Pleistocene or Quaternary	Recent	Alluvium	Meadow. Lintonia loam.
		Glacial	Wisconsin terraces	Miami fine sand.
			Iowa drift	Miami sandy loam.
			Loess	Miami silt loam.
			Buchanan gravels, Kansas drift	No representation.
Paleozoic	Silurian	Niagara	Residual products	
			Delaware	Clarksville stony loam.
	Ordovician	Trenton	Maquoketa	No representation.
			Galena	Clarksville stony loam.

In the Dubuque area the loess is spread over the surface as a veneer that covers hill and valley with unfailing uniformity. It extends from the Mississippi River bluffs to the border of the Iowa drift, and reaches many miles to the southwest of the area. The general elevation in the western portion is much greater than in the east, but there seems to be no difference in the characteristics of the material in different parts of the area. While the thickness of the loess mantle is not uniform, it maintains a general consistency in that the greatest depths occur along the Mississippi River and near the drift margin. It is also thickest on the crowns of the hills and divides, attenuating over the brows and down the slopes. Around Dubuque the mine shafts cut through from 10 to 30 feet of this material, and in all parts of the area the exposed sections are from 2 to 20 feet in depth. It is difficult to state an average figure for the depth of the material over the whole area, but from 6 to 10 feet would not be far amiss.

Typical loess is neither a sand nor a clay, but a yellow silt of intermediate fineness, that consists of certain definite proportions of silica, carbonate of lime, iron, aluminum, etc., and contains nodules of lime and iron (called loess kindchens), ramifying calcareous tubes, and shells of land and fresh-water mollusks. It is homogeneous and free from pebbles and other adventitious material, and is generally rich in lime carbonate, so that it effervesces freely with acid. The carbonate may occasionally be highly magnesian, but it is not to be regarded as derived from the included shells. While the loess is soft and easily cut with a spade or molded in the hand when moist, it resists erosion to a remarkable degree, forming vertical faces which remain intact for long periods of time. Toward the base it generally exhibits a tendency to split along vertical planes, and careful examination exhibits traces of stratification, as shown by series of thin plates that with care may be separated. The uniformity of the particles and the general lack of clay

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impart to the material a friable, open structure that absorbs and holds water much as a sponge does.

The loess of the Dubuque area differs from the typical material in being richer in clay and poorer in the various lime and magnesian carbonates; also in containing a smaller number of nodules and shells. The clay content is greatest in the upper portion of the material, extending from 2 to 6 feet below the surface. The thickness of the clayey band is greatest along the Mississippi River on each side, becoming thinner and less apparent toward the drift border. Here its thickness is usually about 3 feet. The presence of the clay is shown both by the appearance of the material in mass and by the peculiar joint-plane structure which enables it when dry to form small angular clods from the size of wheat grains, or smaller, to that of grains of corn. Along these joint planes it is common to find a thin layer of white powdery material consisting of very fine sand. This may be seen in breaking apart masses of the moist silt.

Determinations of the chemical and mineralogical composition of the loess of different parts of the Mississippi Valley show a variety of minerals, depending upon the kind of rocks from which the soil is derived, as well as variations in the amounts of the different elements. Although these differences occur, as between the loess from Iowa, Illinois, Missouri, and Mississippi, within narrow limits, the composition is quite uniform. From the chapter on loess in the Sixth Annual Report of the U. S. Geological Survey we copy the following chemical analysis of a sample of loess taken a few miles west of Dubuque:

Silica (SiO_2)	76.68
Alumina (Al_2O_3)	12.03
Ferric oxide (Fe_2O_3)	3.53
Ferrous oxide (FeO)	.96
Titanic acid (TiO_2)	.72
Phosphoric acid (P_2O_5)	.23
Manganese oxide (MnO)	.06
Lime (CaO)	1.59
Magnesia (MgO)	1.11
Soda (Na_2O)	1.68
Potash (K_2O)	2.13
Water (H_2O)	2.50
Carbonic acid (CO_2)	.39
Sulphuric acid (SO_3)	.51
Chlorine (Cl)	.09

The minerals that constitute the loess are a large proportion of quartz and feldspar and lesser amounts of orthoclase, plagioclase, biotite, muscovite, hornblende, calcite, dolomite, and some others.

While the origin of this vast sheet of silt is shrouded in mystery, because of the seeming conflict of facts, it is generally conceded that in eastern Iowa the loess was derived from the Iowa glacier. By some

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agency the finer material was carried far beyond the ice margin and deposited over the then existing surface as a comparatively thin sheet. The glacial origin is indicated by the contemporaneous occurrence of the glacial drift and the loess and by the peculiar relative position of their borders, the eastern margin of the drift being the western margin of the loess.

In China the loess seems undoubtedly to have been laid down by æolian action, says Von Reichtofen, but in the Mississippi Valley this force alone would not meet all the facts, and hence from the study of Shimek, Udden, Wilder, and many others, the agency of water is added to that of the air to account for the unique distribution, the homogeneous texture, and the obscurely stratified structure of the material. The most consistent view of its origin seems to be a wind-blown dust drifted in deep, quiet water. The often platy structure, in connection with the massive appearance, upholds this idea. Even this theory leaves some points unsettled, and the problem is still open to definite solution.

SOILS.

The soils of the Dubuque area have been divided into six types, including Meadow. The area of each of these, with the percentage of the total area, is given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami silt loam	176,896	62.8	Meadow	4,160	1.5
Clarksville stony loam	60,672	21.6	Miami fine sand	2,624	.9
Lintonia loam	22,272	7.9			
Miami sandy loam	15,040	5.3	Total	281,664	....

The types which have been recognized are all well defined, and the boundaries of each are sharply marked.

MIAMI SILT LOAM.

In the Dubuque area the Miami silt loam is by far the most prominent type, as is indicated by its occupying 62.8 per cent of the whole area, extending from one boundary to the other in an almost unbroken body. It is the type which determines the agricultural interests of the country and the one preeminent in the production of all the crops that find a place in the farming of the region.

The surface is rolling and hilly and made up of a system of divides, developed by the erosion of the streams, and the soil disappears only where the slope is so steep that it has been carried away by the downward rush of the surface water. The roughest areas are below the

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Niagara escarpment on each side of the Mississippi River, where the soil covers the long, rounded slopes overlying the Maquoketa shales. While making cultivation somewhat difficult, these slopes are seldom so steep as to be untillable, and the whole area is farmed. No extensive level stretches of the type occur in this part of the area, because the shorter streams have channels proportionally deep for the width of the divide. West of the Niagara escarpment and the main divide of the county, where the streams are longer and have a less fall, the divides are broader and the country correspondingly more level. Perfect natural drainage is established on this type throughout the area.

The soil is derived from the weathering of the loess and is practically coextensive with that material. As is indicated by its name the Miami silt loam is composed largely of silt. The surface 12 inches, which is the average depth of the soil, is a friable dark-brown or yellow silt loam, free from gravel or rock fragments. The soil in the region of the steepest slopes has been subject to continual heavy erosion, rendering it thin, somewhat clayey, and less rich in organic remains. In these places it ranges from 7 to 10 inches in depth, and has a light grayish-yellow or reddish-brown color that is particularly noticeable over the brows of the hills, where the most severe erosion occurs. Here the soil is also more clayey in texture. Within the area of the rolling prairie, where the washing and erosion have been less severe, the depth of the soil ranges from 12 to 18 inches, and the color becomes darker because of the accumulation of organic matter. Its greatest extent is along the main divide, where it forms a triangle, with Peosta, Lamotte, and Cascade as the points.

The subsoil of this type is subject to less variation than the soil, consisting of a yellow clayey silt to a depth of 3 feet or more. The clayey stratum has a depth of 2 to 6 feet. This character of the soil is more marked near the Mississippi River than elsewhere. Below the clayey stratum occurs the almost pure silt of the loess, which rests in turn upon the various basal materials of the area, consisting of the residual clay, shales, limestones, and glacial débris.

A noticeable peculiarity of the subsoil is its tendency when dry to form innumerable joint planes that cut the material into small angular clods. Along each of these planes there is found a very fine white sand. Even where the masses of the moist material are broken apart this characteristic cleavage is apparent, and the small eroded gullies show a bottom composed of this flaky mass.

This type of soil in the region of greatest erosion and brightest color is locally called "clay," while the prairie phase is termed "dark loam." It would seem that the term "clay" is almost justified in some parts of the area, as, for instance, in the vicinity of Dubuque and in Menominee Township. There are local areas, notably along the North Fork Maquoketa, where the soil has a grayish-white color when the culti-

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vated land is dried after a rain. In crop value such soil is said not to differ materially from the darker colored soil in the same locality. Extending from near Fillmore eastward to beyond Bernard is an area of 5 or 6 square miles where there is considerable sand mixed with the silt. This is the result of the mingling of the glacial sands with the silt along the border of the drift. Here the slopes are very long and gentle in every part. The soil is a dark silt loam to a depth of 18 inches, containing small amounts of sand. The subsoil to a depth of 36 inches is a clayey sand or in some parts a very sandy clay of a yellow color. Glacial pebbles and bowlders are scattered through the soil and upon the surface.

A similar phase of the Miami silt loam occurs about 2 miles south of Epworth. The crops and yields are the same as those of the surrounding soil.

The texture, structure, and depth of the Miami silt loam combine to give it a most satisfactory relation to moisture. The fine silt particles and the presence of only a small percentage of clay particles enable it to readily absorb a large amount of water and to retain it for long periods, while any excess of water finds its way through the material to the underlying formations. As these are always more or less tilted the drainage is thorough and tiles are unnecessary. The Niagara limestone underlies a large part of this type, and frequently it contains large crevices, particularly near the margins, into which the surface water disappears and is drained away. These sink holes are from 1 to 3 rods in diameter, sometimes occurring in series. Curiously enough, very few of these were noted in the regions of the Galena limestone, probably because the overlying shales are too obdurate.

The friable character of the soil, its wealth of lime compounds, and its general fertility adapt it to the production of grains and grasses. There is no obstruction, save the surface features, to the turning of every foot of it with the plow, at least fair crops being always assured. Its cultivation is free from many of the inconveniences of heavier and lighter soils. No soil can absorb larger amounts of water or withstand more protracted drought with as little evil effect on the crops as can the type under consideration. There are no troublesome clods to vex the farmer, and a suitable seed bed may be obtained with the minimum amount of labor. A tendency toward "heaving" of winter crops by alternate freezing and thawing is one of the worst features of the soil. It also washes badly on the steeper slopes, and against this the farmer must continually guard. A common practice is to leave the hillside draws in grass, the fibrous roots holding the soil in place. Where great gullies have been formed their extension has been checked by brush dams that permit the passage of the water, but so lessen its current that its burden of silt is dropped.

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With the present system of farming the leading crop grown is corn, the yield of which ranges from 25 to 80 bushels per acre, with a probable average of about 45 bushels. To this crop is added a considerable acreage of oats, rye, and grass, the last consisting of timothy and some clover for hay and blue grass for pasture. Barley is occasionally grown. Wheat was formerly produced in considerable quantities and its cultivation is being revived, as has been previously noted. On the more level areas the average production per acre for these crops may be placed at 40 bushels for oats, 20 bushels for rye, 30 to 35 bushels for barley, 18 bushels for wheat, and 1½ tons for hay. For the more broken areas these figures are somewhat above the average. This soil is well adapted to the production of these crops, and with the present system of farming there are a number of forage and other crops that might be added to the list with good results. Among these may be mentioned alfalfa, rape, Kafir corn, and sorghum. Alfalfa deserves especial attention in view of the recent failure of clover.

To the grain and grass crops may be added a number of the small fruits and some tree fruits of the hardier varieties, such as apples, plums, and pears. This soil type will undoubtedly produce these fruits in profusion if moderate care is exercised in the management of them.

The following table gives mechanical analyses of this soil type:

Mechanical analyses of Miami silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6708	2 miles S. of Zwingle.	Dark silt loam, 0 to 12 inches.	2.50	0.06	0.54	0.36	1.34	14.76	70.52	11.32
6704	2¼ miles S. of Menominee.	Grayish-brown silt loam, 0 to 10 inches.	.65	Tr.	.48	.38	1.46	21.28	64.70	11.48
6706	4¼ miles SW. of Dubuque.	Grayish-brown silt, 0 to 10 inches.	2.31	.00	.56	.38	1.26	15.66	69.90	11.72
6710	1 mile E. of Bernard.	Dark sandy silt loam, 0 to 18 inches.	1.68	.56	3.40	5.04	9.06	13.90	49.16	17.94
6702	Cen. W. border sec. 22, Vernon Tp.	Brown silt loam, 0 to 15 inches.	2.67	.28	.50	.30	.60	5.44	72.02	19.18
6707	Subsoil of 6706......	Yellow silty clay, 10 to 36 inches.	.51	Tr.	.22	.36	.72	15.46	72.14	10.86
6705	Subsoil of 6704......	Yellow clayey silt, 10 to 36 inches.	.42	.00	.62	.28	.98	22.22	64.26	11.66
6709	Subsoil of 6708......	Yellow clayey silt, 12 to 36 inches.	.47	.04	.66	.30	.72	13.14	72.14	13.30
6703	Subsoil of 6702......	Yellow clayey silt, 15 to 36 inches.	.84	.00	.30	.22	.30	14.72	70.02	13.36
6711	Subsoil of 6710......	Yellow sandy clay, 18 to 36 inches.	.45	2.24	6.14	5.88	14.16	13.56	31.38	25.48

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CLARKSVILLE STONY LOAM.

Outcrops of the two limestones occur along the rivers and smaller streams in every part of the area, forming steep and often precipitous slopes strewn with rock fragments and cut by projecting ledges of the massive rock. The formations are the Galena and the Niagara limestones, the former giving rise to the bluffs along the Mississippi River and the lower courses of its tributaries, and the latter forming the upper series of steep slopes from which are derived the valley rims and many spurs, such as Table Mound. These outcrops are most numerous and extensive in the eastern part of the area, in the broad gorge of the Mississippi, and in the western part adjacent to the larger streams. They form but a small percentage of the area, as compared with the Miami silt loam, but because of their rough and rugged features they exercise a profound influence on the agricultural value of that and other soils in connection with which they occur.

The Clarksville stony loam owes its derivation and its characteristics to these limestone outcrops. The soil is a rich black silt loam, from 8 to 15 inches in depth, containing from 30 to 60 per cent of limestone and chert fragments. In addition to the silt, which is derived from the washings of the loess, the soil contains more or less residual material, consisting of clay and sand, which imparts something of a sandy loam character to some of the areas.

The subsoil, like the soil, is silty and often quite clayey, due to the greater quantity of residual material incorporated with the loess, while the quantity of rock fragments is increased, ranging from 40 to 70 per cent of the entire mass. Very often bed rock occurs within 2 or 3 feet of the surface. The limestone fragments are of all sizes, from blocks weighing tons to small pebbles, and their shape is quite as variable. They have a cavernous or honeycombed surface, due to the weathering out of the softer portions. As the Niagara limestone contains much the larger amount of chert, it follows that the stony loam of the higher elevations contains a greater abundance of that material, and the surface of some of the areas of the type is practically a mass of these fragments.

The dark color of the soil is due to the high percentage of included organic matter. The subsoil from which this has been excluded is generally a dull-yellowish color. Over the rocky cliffs there is, of course, no soil covering, and in other places only a few inches of silty material rests upon the heavy, intractable residual clay. The extent of both of these phases is small. The type includes the brows of the hills and the lower talus slopes. Since the surface inclination is at such a high angle it happens that the areas are somewhat exaggerated on the accompanying map, where topographic lines have been followed as far as possible.

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The steepness of the surface and the stony character of both the soil and subsoil combine to render this type of little agricultural value. It is almost entirely covered by a sparse, second-growth forest of jack and scrub oak and black aspen, yielding timber of little value. The open character of the growth permits the formation of a fair turf of blue grass, which affords some pasture, and where the timber is removed and the slope is not very steep an excellent natural growth of that grass may be secured. No effort has been made to grow crops other than grass on this type of soil. It would seem that it might be utilized to some extent for the production of grapes and valuable timber trees. The surface should not be left exposed to erosion, and the maintenance of a timber covering is one of the best means for its utilization.

The following table gives the mechanical analyses of soil and subsoil of this type:

Mechanical analyses of Clarksville stony loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6694	3 miles SW. of Dubuque.	Black silty loam, 0 to 14 inches.	1.67	0.10	0.72	1.00	6.54	13.26	72.54	5.74
6692	5 miles SW. of Dubuque.	Black silty loam, 0 to 14 inches.	2.93	.36	.86	.42	1.20	3.88	74.14	18.96
6695	Subsoil of 6694	Light-brown clayey silt, 14 to 36 inches.	.95	.70	2.00	3.14	25.08	19.12	42.34	7.22
6693	Subsoil of 6692	Brownish-yellow silty clay, 14 to 36 inches.	1.13	1.62	1.24	.66	6.70	10.16	57.02	22.22

MIAMI SANDY LOAM.

The Miami sandy loam is found entirely in the western third of the sheet, where it occurs in three elongated areas with a general southeast direction. The first extends from Farley to Epworth, the second reaches from northern Whitewater Township to the vicinity of Fillmore, and the third stretches from Cascade to a point about 3 miles south of Garry Owen. The material is probably of Iowa glacial origin and of morainal character. The surface is rolling and the most southern area follows the course of the North Fork Maquoketa River and one of its tributaries. Near Fillmore it crosses the high bluffs along John Creek. In general the outlines of the surface are rounded,

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and in the two lower areas there is a semblance of the billowy forms due to wind action.

The soil consists of a gray to dark-brown sandy and silty loam 6 to 12 inches in depth, containing occasional angular pebbles. This rests upon a subsoil of brownish to yellow loamy sand at a depth of 20 or 30 inches. The included sand is of medium and fine grade and varies in quantity in different parts of the area. The soil and subsoil are heaviest in the area around Epworth, while in the other two areas knolls of light, loose sand are frequent. The type is particularly variable within itself, the loose, shifting knolls and ridges alternating with the heavier loam areas. The basal material ranges from a light sand to almost a clay, with that indefiniteness which characterizes soils of morainic origin.

The Miami sandy loam is devoted to the production of grain and grass, the yields of which are fair. The natural fertility is sufficient to produce good crops, but the soil is much affected by drought, and hence the returns are largely determined by the rainfall. As compared with the silt loam the crop yields are lower. More careful management for the conservation of soil moisture and fertility are necessary on this type. With such careful treatment truck crops and fruits may be added to the list of crops at present grown.

The following table contains mechanical analyses of typical samples of this soil and subsoil:

Mechanical analyses of Miami sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Find sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6688	½ mile E. of Farley..	Dark sandy loam, 0 to 12 inches.	2.11	1.02	8.24	19.66	31.80	9.56	18.18	10.98
6690	Center of section 25, Whitewater Township.	.....do...............	1.67	.74	9.20	30.08	28.50	2.48	16.74	12.30
6691	Subsoil of 6690.....	Brown sand, 12 to 36 inches.	.52	1.16	9.78	33.00	35.38	1.40	11.00	8.22
6689	Subsoil of 6688.....	Brown clayey sand, 12 to 36 inches.	.74	.40	6.38	19.06	33.30	11.26	18.94	9.80

MIAMI FINE SAND.

The fragments of terraces along the borders in the inner gorge of the Mississippi River give rise to a type of soil that is a few grades finer than the Miami sandy loam. The soil to a depth of 12 inches is a dark sandy loam, the sand consisting largely of the finer grades.

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This rests upon a slightly loamy brownish to yellow sand that extends to a depth of several feet. The phase above the bluff is lighter in texture and color, and of a more uniform fineness, and is free from the occasional pebbles that occur at the lower levels. In all areas there is a tendency toward loose, shifting sand, knolls of which are frequently found.

The main area is below the bluff southeast of Dubuque and on the east side of the river, where the surface slopes from an elevation of 640 feet to the level of the river channel at the water's edge. This area extends for 5 miles along the river. On the west side of the river is a similar body of soil, upon part of which is situated the town of Dubuque. Farther south the only areas of the type at these levels is a narrow ribbon of sand at the foot of the cliff. In addition to the areas already mentioned there occurs a long, narrow strip of a modified phase of this soil on the bluff on the Illinois side of the river. In this situation the soil is derived by wind transportation from the terrace sands. It rests on the loess formation, and has a rolling, billowy, dunelike surface. The surface of the type at lower levels is less rolling, but yet is gently undulating.

The greater part of this soil is under cultivation, and fair crops of grain and grass are grown. Its light and open character renders it especially susceptible to the effects of drought, and careful management is necessary to maintain the naturally high fertility of the terrace areas. Besides the grain crops it may also be expected to give good yields of all the truck crops suited to the climate.

The following table shows the texture of typical samples of this type:

Mechanical analyses of Miami fine sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6696	3 miles SE. of Dubuque.	Brown fine sandy loam, 0 to 12 inches.	1.30	0.70	4.94	5.64	45.60	29.54	9.24	4.44
6698	3 miles SE. of Dubuque.	Sandy loam, 0 to 18 inches.	1.32	.58	20.78	27.50	28.42	6.50	8.92	7.24
6697	Subsoil of 6696....	Fine yellow sand, 12 to 36 inches.	.21	.24	3.74	4.88	51.96	31.20	4.02	3.92
6699	Subsoil of 6698....	Brown, slightly heavy sand, 18 to 36 inches.	.64	.32	17.42	25.96	35.58	10.32	5.86	4.50

LINTONIA LOAM.

All the streams except the Mississippi River are fringed by a ribbon of low, flat land of varying width. The soil of these areas is col-

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luvial, derived from the wash of the slopes at higher elevations. It occupies the position in which is generally found wet meadow land, but on the whole differs from the latter in being quite level, comparatively well drained, and much more uniform in texture. Through this bottom land the main channel of the stream winds between almost vertical walls. The areas of this soil are occasionally overflowed, but rapidly recover from the effect of the flood and where of sufficient extent are cultivated.

To a depth of from 3 to 6 feet the Lintonia loam consists of a dark to black silt loam, interstratified in some parts with thin layers of fine sand. Through the areas of sandy loam the soil is of a more sandy character. The percentage of organic matter is always high. In the eastern part of the area surveyed, where the stream valleys have a steep slope riverward and flow between rocky walls, the soil material rests upon a mass of rock fragments. Farther west the basal material is a silty wash, sometimes of a yellowish color.

The limited extent of this type and the fact that it is often bordered by the stony loam have led to its general use as pasture land only. It is very fertile, yielding excellent crops of all the grains and grasses and capable of producing a variety of truck crops.

The largest areas are found in the western part of the area surveyed, usually at the head of streams, south of Epworth and between Bernard and Fillmore. These were originally wet, mucky quagmires that are just now becoming sufficiently dry to permit cultivation.

The following table shows the texture of this soil:

Mechanical analyses of Lintonia loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6701	3 miles SW. of Dubuque.	Black silt and fine sandy loam, 0 to 36 inches.	4.83	0.28	1.58	3.12	22.28	12.62	50.82	8.74
6700	3 miles SW. of Lamotte.	Black silty loam, 0 to 36 inches.	3.59	Tr.	.54	.32	1.22	6.76	79.34	11.80

MEADOW.

The extent of meadow land in the area is small and is confined mainly to the lower portion of the inner gorge of the Mississippi River, where occur a number of low islands cut off from the shore by side channels and bayous. The nearness of standing water to the surface, added to frequent overflows in times of high water, renders

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this type of little present agricultural value. The material is a variable mixture of sand and silty mud that has been dropped by the water as its current was checked, and until the process of soil formation has gone far enough to raise these areas permanently above the flood level they will continue to be, as they now are, useless lands as far as agriculture is concerned.

AGRICULTURAL CONDITIONS.

The generally well kept farms, commodious farm buildings, and modern machinery seen throughout the area indicate a fairly prosperous condition of the agricultural classes. A large proportion of the farmers are of foreign parentage, and their thrift and industry have built up a profitable system of agricultural practices. The farms as a rule have a large acreage, ranging from 150 to 600 acres on the more level uplands and from 100 to 400 acres in the vicinity of Dubuque. There are smaller holdings, but the number of such is limited. The idea of extensive farm operations, which seems to dominate the farmers, has led to the use of many-horse teams and wide-cutting implements and to the sacrifice of thoroughness and efficiency, sometimes, for rapidity.

The present value of the farms ranges from $40 to $80 per acre, depending on the proportion of uncultivable land and the distance from market and the direct means of transportation. Land values are at present increasing. The farms are tilled largely by the owners, but some renting is also practiced, both for a share in the products and for a money rent. The latter method is becoming more general. Farm labor is done mainly by the farmer and his family, hired labor being scarce and commanding wages ranging from $20 to $30 per month with board.

The general system of farm practice is based upon the production of grains and grass, which are almost entirely fed to live stock, and thus marketed in the form of meat, wool, and dairy products. The foremost crop in acreage and yield is corn. This is the mainstay of the farmer and is never a complete failure. It is said that during the season of 1901 one-half to two-thirds of a full crop was produced without an effective rain during the growing season. The yield of corn varies somewhat in different parts and upon the different soils of the area surveyed. The dark loams on the prairie produce from 35 to 80 bushels and the remaining area gives from 25 to 65 bushels per acre. Besides corn a considerable quantity of oats and some rye and barley are produced. The hay crop is a large one, consisting of timothy and clover, mixed and separate. During the last three years difficulty in securing stands of clover, together with winter injury of the young plants, has greatly reduced the acreage of that legume, and a substitute that will withstand the rigor of the climate is needed to balance

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the dairy and beef rations and keep up the fertility of the land. It would seem that alfalfa, a legume comparing favorably with clover in all particulars, might be introduced. The yields of hay vary between 1 and 2 tons per acre. For pasture, blue grass is commonly used. This is well adapted to all the silty soils, and occupies the soil naturally within from three to six years, forming a dense, thrifty sod. The hay meadows also furnish a limited amount of pasture.

Throughout the county there is a noticeable absence of orchards and of fruits of all kinds. At long intervals one may see a few old apple trees that have almost passed beyond bearing, but of other fruits there are none. The general farm operations claim all the attention of the agriculturist and the care that is necessary to enable fruit to withstand the severe winters and numerous insect enemies is not forthcoming. In the southern part of the area, at a number of points around Cascade, Bernard, Zwingle, and St. Donatus, small plantings of apples have recently been made and the trees appear thrifty.

The river bluffs are among the best fruit lands in the State of Iowa, the only difficulty being an occasional winter of unusual severity which kills all weak trees. Such a one was the winter of 1898–99, when not only fruit but forest trees were killed or permanently injured. In view of this only hardy varieties of fruit should be planted. It would seem that at least enough fruit should be produced to supply the home demand, and there are possibilities for development of the industry on commercial lines.

The live stock on the farms consists mainly of cattle and hogs. The cattle raised are both for beef and for dairy purposes. The milk is largely manufactured into butter in central factories, of which there are nine located in the area. The skim milk is returned to the farm and used for feeding calves and pigs. There is little distinction between the two types of animals used for dairy and for beef purposes, as they are of mixed breeds, with a possible predominance of Shorthorn blood. The hogs also are of mixed breeds, though there is a general predominance of the Poland-China characteristics. It is generally conceded that the different breeds of live stock have been so developed that they are adapted to particular uses; that an animal of the beef breeds is not a profitable one for the dairyman, and that in every instance most satisfactory returns are derived from animals whose pedigrees show that they have been kept close to the established strains. In this particular the horses in use in the area show an adaptation of the animal to the work, for the farm horses are large, muscular, and well built for draft purposes, but in case of cattle and swine there is opportunity for great improvement.

The roads are hilly and irregular. The topography of the country is such that land lines could not be followed, and even with the present system the frequent steep grades are a serious impediment to hauling

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even moderate-sized loads. Besides being steep the roads are almost entirely composed of earth, using the material nearest at hand, and hence they are largely clayey and easily affected by rains or frost. Every hill is a mass of limestone, one of the best road materials to be had, and with a crusher in each township great improvement in the roads might be cheaply brought about.

Railroad transportation facilities are better. There are four lines of railroads that touch or cross the area. The Illinois Central and the Chicago and Northwestern traverse the northern part of the area, the Chicago, Milwaukee and St. Paul follows the river south, from which a narrow-gauge branch reaches from Bellevue to Cascade, and the Chicago, Burlington and Northern runs into East Dubuque. There is also a line of boats on the Mississippi River. With all these means of connection with the centers of Eastern and foreign trade the facilities for marketing the produce of the area are remarkably good. The live stock produced is within seven hours' run of the greatest slaughtering houses of the world, and the duplicate lines insure fair rates for these as well as for grain shipments. The butter manufactured in the creameries is shipped to Chicago and New York.

The chief opportunities for improvement are along the lines of industry already established and lie in the introduction of a better breed of live stock, in the adoption of a less extensive system of cropping, and in the improvement of the soil by a larger use of leguminous plants in the rotation. In the past no commercial fertilizers have been used and none seem very necessary. Stable manure is saved and returned to the land. There is some loss in the handling of this that might with a small degree of care be prevented. The agricultural conditions compare favorably with those in other areas that have been surveyed.

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SOIL SURVEY OF HOWELL COUNTY, MISSOURI.

By ELMER O. FIPPIN and JAMES L. BURGESS.

LOCATION AND BOUNDARIES OF THE AREA.

The Ozark Uplift involves almost the whole of Missouri south of the Missouri River and a considerable portion of northwestern Arkansas. Over this vast area there are features of topography and characteristics of soil common to every part. In Missouri one series of rocks, the Cambro-Silurian, occupies the greater part of forty-two counties,

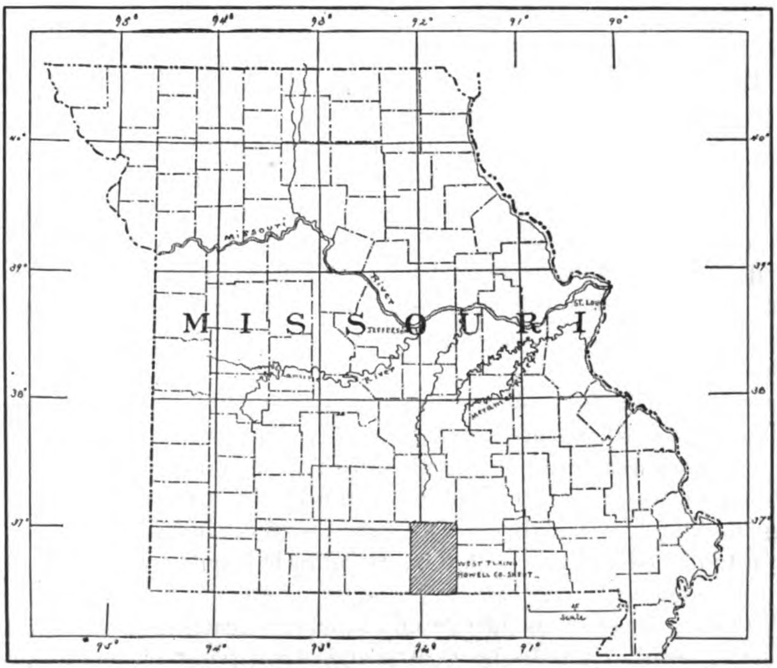

FIG. 16.—Sketch map showing area surveyed in Missouri.

and these by processes of weathering and erosion may be relied upon to give similar results in physiography and soil conditions. The area surveyed occupies a position nearly central in this extensive plateau, for such it is, and a little to the southeast of the point of highest elevation. Because of the relation which the soils of the area surveyed bear to the adjoining territory, the present survey has a double value; it shows the exact soil conditions of Howell County, and is also an index to the soil conditions of much of the surrounding region. (See fig. 16.)

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Howell County, containing 919 square miles, or 588,160 acres, is situated in the south-central part of Missouri, and borders Arkansas on the south. It is crossed in the northern part by parallel 37° north latitude and in the western part by meridian 92° west from Greenwich. The area is rectangular, with a length north and south of 38 miles and a width east and west of 24 miles. Texas County borders the area on the north, Shannon and Oregon counties on the east, and Douglas and Ozark counties on the west.

The largest town and chief center of trade is Westplains, a city of about 3,000 inhabitants, situated near the center of the county. Willowsprings is second in size and importance. Other villages, so called, are little more than crossroads post-offices.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

As late as 1850 the Indian was almost the sole inhabitant of this country, though a few homestead tracts had been occupied by white settlers. The country was then an expanse of rolling territory without forest, but with groves of scattered oaks, mainly white, post, red, and black oak. Everywhere the prairie grass—the big blue-stem—grew in rank profusion and of a height at maturity to conceal a horse and his rider. Each season the grass sprouted anew, matured, and fell down, to be burned to make way for the next season's growth. Each season innumerable sprouts of oak sprang up, but the annual fires destroyed these, leaving only stunted roots that grew to be immense "bench grubs."

In certain belts, notably one extending from Burnham and Willowsprings westward to the county line, and, less extensively developed, in the eastern quarter of the north half of the county, existed valuable yellow-pine forests. The growth was not thick, but the trees were of large size and good quality. The grass in the pine forests was less well established and less rank, but still afforded some covering for the soil.

With the advent of the farmer and ranchman, each spring found the country grazed by hundreds of cattle and other live stock that cropped the grass close, leaving but a small part of the growth to mature. The oak sprouts were present as before, but when the fire was started and the dead stems burned there was not sufficient heat developed from the reduced amount of rubbish to kill all of them. Gradually, year by year, the sprouts got a better hold on the land, until finally millions of oak saplings—mainly black-jack—occupied the place of the prairie grass. These saplings made their advent during the decade from 1870 to 1880, when the country became a flourishing commonwealth, and now constitute well-developed forests. At the present time probably more than 60 per cent of the county is timbered.

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The greater part of the area was opened to settlement by the homestead act, under the terms of which much of the land was taken up and is still held. In the northwestern part of the area are several thousand acres that were granted to the present State University of Missouri when it was organized as a land-grant college. This land passed into the hands of a private company, which, after removing all the valuable timber, sold out the greater part of the tract to farmers or to mining companies.

Some land in the county is still open to homesteaders, but it is of the most undesirable character.

As has been intimated, the grazing of cattle at first formed the chief industry of the farmers of Howell County, but with the decrease in the extent and depreciation in quality of the public range, grain farming assumed first place in the local agriculture, both in acreage and value of product. In this line of agriculture there has been no noticeable change since its advent, the same crops—corn, wheat, oats, rye, and timothy—being grown now as formerly.

About 1882 an agricultural interest new to the region—fruit growing—was introduced into Howell County. This industry has since spread to other parts of southern Missouri, which has become famous for the quality of its fruits. Col. J. C. Evans, whose attention was first called to the possibilities of the soils of the region for fruit growing, while passing through the country with his regiment during the civil war, planted the first commercial orchard of peaches and apples at Olden, near the center of the county. His experiment was a success, and furnished the basis for the orchards that now reach from Springfield to the border of the State, following in general the line of the St. Louis and San Francisco Railroad. The original Olden orchard still exists, and additions have been made until it now contains some 1,300 or 1,400 acres, and although others of even larger extent have been established in the region, this one continues to be the largest in Howell County. New orchards are being set out each year.

About the same time as the Olden experiment (1883) Mr. Philip Brand established a large vineyard near the present town of Brandsville. This venture also proved a success, and new vines have been added to the vineyard from time to time until it now covers 65 acres. Experiment has shown that wine grapes are most profitably grown, and they now occupy the whole area. Other smaller vineyards have been established on the strength of the success of this first one.

CLIMATE.

While the temperature records show considerable range throughout the year, the summers are usually not excessively hot nor the winters extremely cold. But little snow falls, and this seldom remains long on the ground. The winter season is best described as a succession of

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alternating periods of moderately cold and comparatively mild weather. The rainfall is well distributed through the year, but periods of drought are not infrequent, though usually not of sufficient length or severity to do general injury to the crops.

The following table gives the normal temperature and precipitation by months and for the year. These records are from the Weather Bureau station at Olden:

Normal monthly and annual temperature and precipitation.

Month.	Temperature.	Precipitation.	Month.	Temperature.	Precipitation.
	° F.	*Inches.*		*° F.*	*Inches.*
January	35.4	2.44	August	76.4	2.72
February	33.8	3.21	September	70.2	3.12
March	45.9	5.31	October	59.6	2.40
April	57.6	4.53	November	46.1	2.88
May	65.7	4.39	December	36.9	2.34
June	73.9	3.45	Year	56.5	40.67
July	76.7	3.88			

In the late fall and early spring there are occasional unseasonable warm spells, which force the frui buds unduly and render them liable to damage by freezing. From the somewhat fragmentary records of the station at Olden it is seen that killing frost may come as late in the spring as April 23 and as early in the fall as September 18. The average dates of occurrence are April 13 and October 21. This gives an average growing season for tender vegetation of one hundred and sixty-one days.

The success with fruit in this area shows that the climatic conditions are in the main highly favorable to the industry.

PHYSIOGRAPHY AND GEOLOGY.

The area forms a part of the large elevated region known as the Ozark Plateau. The originally level surface of this plateau, subjected to weathering and erosion since early geological time, has been carved and chiseled into a vast system of water courses, some with deep, narrow gorges, and others more shallow and with broad bottoms. The part of the plateau situated within Howell County has an elevation above sea level of from 900 to 1,300 feet, with a general slope to the south and east. Through the central part of this area extends a broad divide whose general trend is northwest and southeast. This divide enters the county near Sterling, passes about 4 miles west of Westplains, and leaves the county near Brandsville. With the exception of a small knob or two the greatest elevation of the ridge is in the vicinity of Burnham, and a considerable elevation is retained

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throughout the distance from that place to Olden, the difference being less than 100 feet.

The surface of this plateau is rolling and hilly. Nowhere in the country do there occur very extensive level areas. Along the main divide the country has a gentle swell which in a few places gives way to comparatively level stretches, such as occur a few miles southeast of Westplains. On the minor divides there are also level areas, conspicuous by contrast, in the vicinity of Moody and Peace Valley. Off the divides along the borders of the county the country is very rough and rugged. In general the southern half of the county is more level than the northern half. Two prominent peculiarities of the topography, common to all parts of the plateau, are the rounded knobs that rise above the surrounding country as dome-shaped hills, and the bowl-shaped depressions of variable extent and depth known as sink holes. Typical of the former is Kings Mountain, lying east of Willowspring. This eminence is the highest point in the county, attaining an elevation of 1,440 feet. Sometimes these knobs occur in chains along the crests of narrow divides, as seen in the vicinity of Silver Springs. Their existence is traceable to two causes—the obdurate character of the cherty materials of which they are composed and the arrangement of the local drainage systems, which are not necessarily the result of structural differences in the country. The sinks are formed by the falling in of the roofs of superficial caverns in the limestone and are frequently occupied by ponds of water.

Thorough drainage is attained in every part of the county through a complete system of ramifying streams and draws. These divide and subdivide until they end in ravines or gullies in the highest hills. The largest streams are Eleven Point, Gunters, Warm Fork, and Wyatt creeks in the eastern half of the county, two tributaries of South Fork in the southern part, and a half dozen tributaries of Spring River in the western part of the county. With the exception of the lower course of two or three of these streams, they are all dry during the greater part of the year, serving only to carry away the excess of water during freshets. A few springs are found along the courses of all the streams.

As already pointed out, the walls of these streams may be either precipitous or very gently sloping. In the interior of the county they are most commonly very low and with a gradual slope, while practically every stream leaves the county in a deep gorge. In this latter position they are often lined by tortuous rock walls, but without any of that castlelike and columnar carving seen in regions of less age. In fact that feature is entirely absent from the county. The process of weathering has progressed beyond such forms, and their former presence is indicated only by piles of chert—the most resistant part of the

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original strata of stone composing the plateau. The steeper slopes are frequently covered by these chert fragments.

The topography of the area exercises a marked influence upon its agricultural development, hindering it in some ways and helping it in others. The rough surface is an obstacle to cultivation and the use of modern implements in general farming, but to the fruit grower such a surface is of benefit, in that it insures air drainage and reduces the danger of frosts and heavy freezes.

The rocks from which the soils of the region have been derived are of sedimentary origin and belong to the Cambro-Silurian series. These rocks consist of alternating strata of limestone and sandstone, of which exposures 100 feet in thickness have been noted. The geology of the county has never been studied in detail, so that very little information is available on the subject. The limestone is of a light color, somewhat magnesian, and usually quite cherty. Intercalated with the limestone thin strata of sandstone sometimes occur, and irregular masses of fine-grained and kaolinitic rocks are found. The limestone rocks are the most common, occurring in every part of the area and at the highest elevations. From their breaking down come the cherty bowlders which lie strewn about over the surface or form knoblike masses, frequently of considerable height.

The sandstone varies from a medium to a very fine grained texture. It comes to the surface mainly in the bottoms of the deeper stream channels in the western part of the county. It is of a siliceous character, and masses of quartzite are frequently included. Much of the sandstone is composed of exceedingly fine sand.

SOILS.

The soils of the area are derived almost entirely from the breaking down of the limestone and associated rocks by the agencies of general weathering and erosion, the sandstone contributing in an almost negligible proportion. The materials resulting from the decomposition of these limestone rocks are all quite clayey in texture and are stained strongly with oxide of iron, especially where not subject to much leaching by rain water. More or less sand and silt is mingled with the clay, the former frequently occurring in pockets. The depth of this residual mass is variable and ranges from nothing, over the crests of a few hills, to more than 50 feet in places where the soil has accumulated. Through the soil mass the more resistant cherty part of the rock is scattered in proportion as it occurred in the original rock, though generally most abundant on the surface.

Because derived from a common rock acted upon by the same conditions, in every part of the county the soils are comparatively uniform over large areas and show a well-marked relationship to one

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another. But three types were found in the area, as given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.
Clarksville stony loam	499,264	84.89
Clarksville loam	48,512	8.25
Clarksville silt loam	40,384	6.86
Total	588,160	

CLARKSVILLE STONY LOAM.

The Clarksville stony loam is a loam of grayish or yellowish color, with a depth of 7 inches, resting on a heavier yellow loam extending to a depth of from 15 to 25 inches, where it gives way to a stiff red or reddish clay that is continuous downward for several feet. The upper 15 to 25 inches of soil is noticeably silty, and particularly so in the surface few inches.

From the surface downward there is a gradual increase in the clay content, until the material becomes distinctly a clay. The clay varies from a dark reddish brown to a yellowish red, there being no regularity in the distribution of the different shades of color.

The soil of this type contains from 10 to 65 per cent of chert and sandstone fragments, the chert largely predominating. The proportion of the two rocks differs in different parts of the area. In the subsoil the quantity of rock is less than in the soil, the proportion varying from 5 to 30 per cent. The fragments are most plentiful on the surface, frequently forming a continuous carpet. Under cultivation the fragments and bowlders, generally not of large size, become mixed with the soil or, as sometimes happens, they are picked off and form a much less conspicuous feature of the type. As indicated by the percentages already given, there is a wide variation in the quantity of rock present in different areas of the soil. There are considerable areas, lying chiefly along the larger streams, that are so rough and rocky as to be impracticable of cultivation. These areas have been indicated on the map by rock symbol. (See Pl. XXXIII.)

The presence of sandstone in the area has supplied the small proportion of sand disseminated through the soil and subsoil, but particularly the soil, of this type. The sand content is not high enough to influence the crop value of the soil except in a few isolated places, and its general occurrence will be considered further on in this report.

The Clarksville stony loam is by far the most extensive type in the area. It occurs in every part of the county and occupies almost 85 per cent of the whole area. It may be considered as a continuous

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body of soil with the other types cutting through it at irregular intervals or occurring in limited areas in its midst.

The surface of this soil type has nearly all the characteristics of the topography of the county in general. It is rolling and hilly, with occasional comparatively level stretches. The type covers all the divides where the most level areas are found, as well as areas along the streams, where it is most rough, and includes all the slopes suitable for cultivation to ordinary crops.

The forests, which cover a large part of this soil, consist of black, white, red, and post oak, hickory, and yellow pine. While the "blackjack" or black oak is found in all parts of the county, it is most abundant on the divides where the red clay comes nearest the surface. Indeed, the size and abundance of this oak may usually be taken as an indication of the near approach of the red clay to the surface. As a rule, also, those areas are the most fertile parts of the type. The other species form more open forests and occur most abundantly nearer the borders of the county, where the topography is most broken. In this part of the county some forests occur on the other upland soil types. No soil differences to account for the distribution of the pine forests were apparent.

Parts of the most level uplands that have a considerable growth of white oak are termed "white-oak flats," and similar names are applied to other areas having a predominance of other species of trees.

The complete system of stream courses and the general rolling character of the country insure thorough surface drainage. Any excess of surface water is rapidly carried away. The movement of water through the soil is not particularly rapid, because of the heavy underlying clay, but the surface 2 feet takes up water readily, so that a heavy and rather prolonged rain is necessary to start the surface flow of water. By properly compacting and puddling the soil may be made to retain water for indefinite periods, and this feature is made use of in constructing ponds to collect water for stock.

The immense strata of limestone, with the associated kaolinitic rocks found throughout the county, are the source of the soil, which has been derived through processes of weathering and erosion. The soluble constituents of the rocks have been carried away by running water, and the insoluble or slightly soluble residue left behind, forming the soils as they are to-day. In the process of weathering the most resistant parts of the rocks, mainly chert, were unaffected and remain intact in the residual mass. These cherty particles are found scattered through the residual clays, sometimes only as small fragments, in other places forming sheets of varying extent and thickness. These sheets may be broken into numerous fragments, although remaining approximately in place. The fact of common observation that the rock fragments are most abundant on the surface is to be attributed to constant washing and erosion, which carries away from the surface the fine

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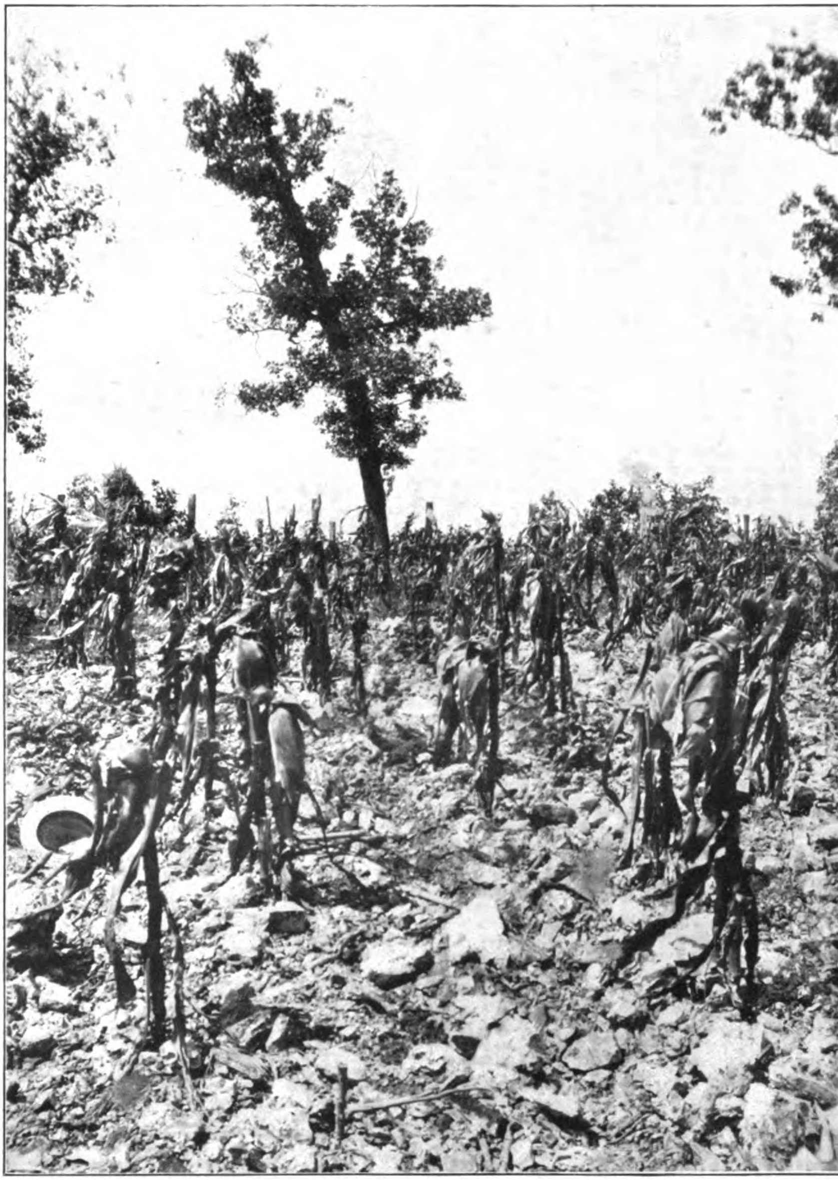

THE CLARKSVILLE STONY LOAM, HOWELL COUNTY AREA, MISSOURI.

Showing the very stony character of the soil, which is poorly adapted to general farm crops, but well adapted to apples and peaches.

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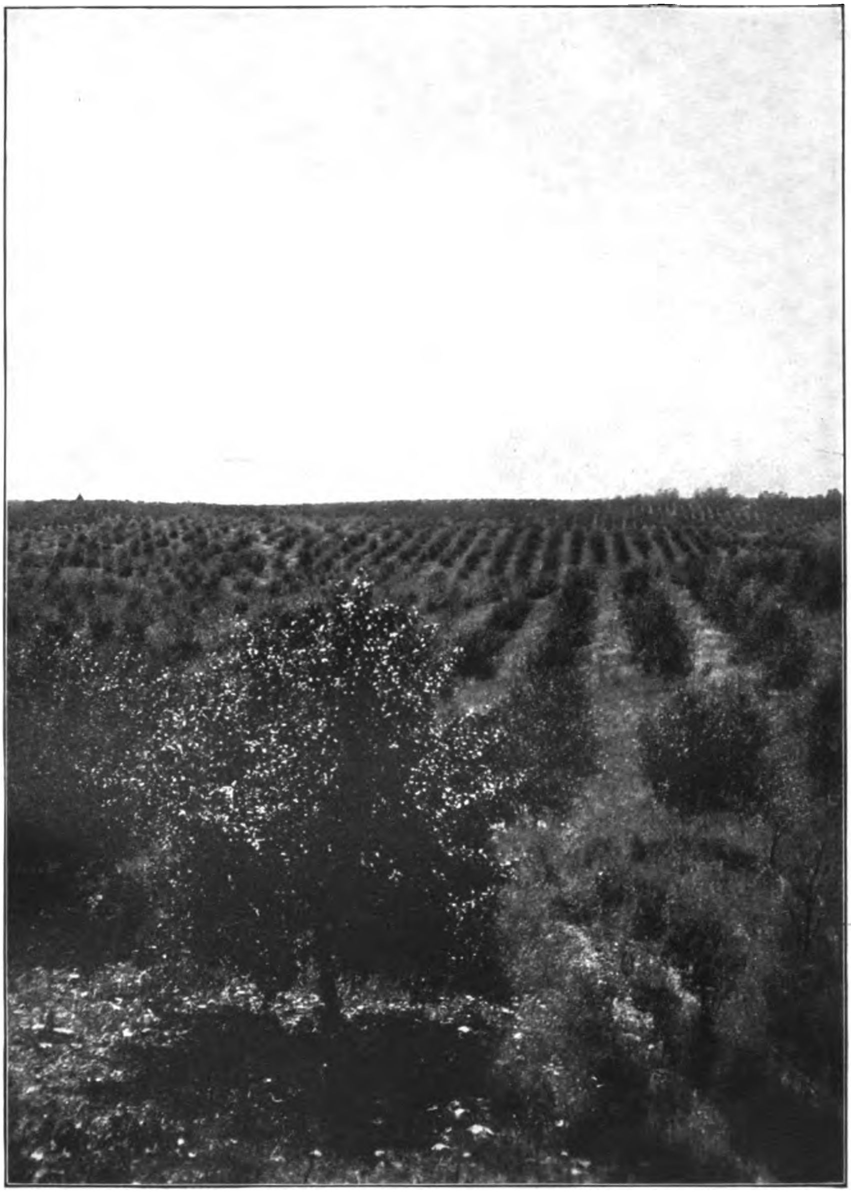

VIEW OF APPLE AND PEACH ORCHARDS ON THE CLARKSVILLE STONY LOAM, HOWELL COUNTY AREA, MISSOURI.

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earth, leaving behind the stony material too heavy to be deported. This accumulates year by year until it covers the surface. This theory makes plain why the stones are more abundant on the slopes than on certain flat uplands. Of course it must be remembered, too, that the quantity of the material originally in the rock is an influencing factor.

The presence of the rock fragments is said to improve the yields of crops, and they are held to be generally beneficial except where numerous enough to cause inconvenience in cultivation. During heavy rains they retard washing. They prevent the baking of the surface as the soil dries, and during droughts serve as a mulch, preventing the escape of moisture.

The general red color of the subsoil and the yellowish color of the soil are due to the influence of oxides of iron which have been concentrated in the soil during the processes of weathering and erosion. To such an extent has this process of concentration taken place that in many places iron ore of high quality has been formed. This ore appears sometimes as fragments on the surface, while at considerable depths large masses of the ore have been exposed.

The general absence of the darker red color in the surface foot or two, particularly in the most hilly parts of the area, is due to the leaching of the rains, which has carried away much of the iron and changed the form of the oxide in the part remaining.

The crops produced on this soil are chiefly the grains and grasses, which are most important in extent and probably in total value, and fruit, which has gained for the region a prominent place in the fruit areas of the United States. (See Pl. XXXIV.)

The average yields of the grains and of hay are moderate, in correspondence with the moderate fertility of the soil. They also are influenced to a large extent by the annual rainfall and its distribution. The average yield per acre of wheat ranges from 8 to 10 bushels, that of corn from 15 to 30 bushels, and of the chief hay grass—timothy—from 1 to 1½ tons. The yield of rye is about that of wheat, and of oats from 12 to 30 bushels per acre. Of the leguminous plants clover and cowpeas are grown, but the droughts do considerable damage to these crops, and the total production is small. About 1 ton per acre is regarded as an average yield. Cowpeas make but a moderate growth, standing only from 1 to 2 feet above the surface of the ground at maturity.

Cotton is grown to a limited extent in the extreme southern part of the county, but the yield of lint is small, ranging from 150 to 300 pounds per acre.

Tobacco finds a place on many farms on this type of soil, but only in small patches, and the product is not of commercial importance. It is a heavy type of tobacco, used for smoking and chewing, and is consumed entirely at home. The growth of the plants indicates that the production of a heavy export and smoking tobacco might be developed into a profitable industry.

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The fruits most extensively grown in the area are the peach and the apple, and the orchards are almost entirely limited to the Clarksville stony loam. The fruit is uniformly of large size and superior quality, while the color is especially attractive. If there is any difference in the adaptation of fruit to this soil the peach succeeds better than the apple, but the difference is not great. The other fruits grown are the pear, plum, strawberry, blackberry, and raspberry. These small fruits do not succeed as well on the upland soil as on the soil of the bottom lands, to be described later.

Grapes of all kinds thrive on every part of this type, and are generally considered to be the best adapted to the soil of any of the fruits grown.

Considering the type as a whole, the tree fruits and grapes are better adapted to it than any other class of crops. The soil is not suitable for crops making a heavy draft on its fertility each season, and if the grains are to be grown successfully care must be taken to maintain and increase the supply of available plant food. The soil is deficient in organic matter, and every effort should be made to increase the amount of this material. Even fruit would be benefited by practices that will add organic matter to the soil. The leguminous plants should be more often included in the rotation of crops, and either plowed under in entirety or the hay fed to stock and returned to the fields in the form of manure. The clovers, cowpeas, vetch, and like crops are some of the best soil renovators, and by using these the farmer will materially increase the returns from all the other crops. It also seems that in connection with leguminous crops commercial phosphates and potash fertilizers can be used advantageously on this soil type.

The description of this type would not be complete without particular mention of certain variations occurring here and there in the area. The occurrence of more sandy areas of the soil has been mentioned. In a general way the type is more sandy toward the borders of the county than in the interior. Particularly is this true in the northern part of the county, from near Willowsprings eastward to Mountainview; in the eastern part of the county, south of Gunters Valley; and at various points in the southern part of the county. In these localities the sandstone bowlders are more abundant on the surface than in other parts of the type, and the sand is seen as small bars in washed places and in the roads. Examination of an ordinary section of the soil reveals very little sand except in a few small areas. West and a little to the south of Brandsville, centering in the northern part of section 22 of that township, occurs an area of about 2 square miles that is distinctly sandy. The surface 8 inches is a heavy sandy loam of a whitish color. The yellowish upper subsoil is also sandy. Other similar areas of smaller size are found in the vicinity of Moody. The timber growth on these sandy areas is the same as on other parts of

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the type. Crop yields are also the same, except that shallow-rooted grain crops are more readily affected by drought than where the soil is heavier.

Another variation of importance is seen in many small areas, ranging from a few rods up to an acre or more in extent, scattered throughout the type, where the soil conditions are such that all crops make but a small growth. These spots may be noticed in the forest, in the field, or in the orchard. Forest trees are absent or stunted; fruit trees grow slowly, are stunted in appearance, and are short lived. The particular soil conditions responsible for such a condition of the vegetation are not uniform. Most commonly the cause is in the subsoil, the soil being of the typical material, but the subsoil consisting of an impervious, almost impenetrable mixture of a whitish clay and fine black or brownish pebbles or gravel. These give rise to the term "buckshot land," applied to such soil. Again, some of these places are due to the presence of a most tenacious light-colored clay. At other points the occurrence of thin layers of rock at a depth of 18 or 20 inches below the surface may account for the inferior character of the vegetation. In the vicinity of Sterling are found small areas of a very white and pure clay, which also occurs mixed with the red clay in contiguous areas.

These areas are the result of the gradual process of erosion to which the country has been subject and represent ancient pools—possibly sinks—in which the peculiar materials have accumulated.

The following table gives mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Clarksville stony loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7622	4 miles SE. of Cureall.	Grayish clayey silt to yellowish silty clay, 0 to 22 inches.	0.70	0.70	0.80	2.96	12.00	3.70	61.88	17.72
7624	1 mile NW. of Brandsville.	Grayish-yellow to red silty sandy loam, 0 to 18 inches.	.57	1.42	2.14	4.72	15.92	5.06	52.10	18.04
7625	Subsoil of 7624......	Red stiff clay, 18 to 36 inches.	.18	1.02	1.24	2.68	10.48	3.02	43.00	38.26
7623	Subsoil of 7622......	Red stiff clay, 22 to 36 inches.	.32	1.00	1.86	1.30	5.56	7.14	43.22	39.20
7629	¾ of a mile N. of Pomona.	Red silty clay, 18 to 36 inches.	.31	.60	.84	1.06	3.40	1.84	38.58	53.20

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CLARKSVILLE SILT LOAM.

The Clarksville silt loam is a loam of grayish or yellowish color with a depth of 7 inches. The subsoil is usually a yellow loam of heavier texture, varying in depth from 15 to 25 inches. Beneath this is found a stiff red or reddish clay, which usually extends several feet before the basal rock is reached. The upper soil is quite silty, and especially the immediate surface. This soil differs from the Clarksville stony loam chiefly in the absence of rock fragments.

The drainage is generally good, and because of the absence of rock this type is more easily cultivated than any other in the area. The crops grown are about the same as those on the Clarksville stony loam, and the yields are generally about the same, although the yield of wheat is probably somewhat larger.

The following analyses show the texture of the soil and subsoil of this type:

Mechanical analyses of Clarksville silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7626	7 miles SW. of Westplains.	Yellow silty loam to stiff red clay, 0 to 24 inches.	0.60	0.66	2.04	4.46	9.74	2.88	59.16	20.66
7627	Subsoil of 7626	Stiff red clay, 24 to 36 inches.	.28	.34	1.22	4.34	10.06	3.34	55.76	24.94

CLARKSVILLE LOAM.

The Clarksville loam is a rich yellowish or brown silty loam, 10 inches in depth, resting on a heavier yellow loam which reaches to a depth of 36 inches or more. The subsoil is usually quite silty.

The type is found distributed throughout the area in narrow ribbons along the streams, where they have any considerable width of valley. It constitutes the "bottom land" type of the area. The largest areas occur in the valleys of Hutton, Eleven Point, Gunters, and Howell creeks and their major tributaries. Extensive areas of this type occur around Westplains and in the Pottersville Valley. Besides its occurrence along streams there are a few very small areas found in connection with sink holes in the uplands, chiefly in the region between Whitechurch and Pomona.

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In contrast with the upland soils the Clarksville loam contains few rock fragments of any kind. Near the heads of the valleys there sometimes occurs considerable gravel, and the soil covering is often thin. In the larger valleys the gravel is frequently present as narrow irregular lenses or strata. The original forests included a larger variety of species than the upland forests, adding to the list already given the elm and sycamore. At present the timber is practically all removed and the type is entirely under cultivation.

These low lands are subject to occasional overflow during periods of freshet, though in the larger valleys a general flooding is comparatively rare. The soil is generally well drained, and those areas containing bands of gravel near the surface may even become very dry after a short period of drought. Normally, however, the soil takes up and retains a large quantity of moisture, and the crops are able to withstand prolonged drought without suffering much injury.

The materials constituting this soil type are derived from the wash of the upland types. The small gullies on every hillside become torrents during heavy rains, and in its movement down the slope the water carries away the soil and the smaller pebbles and stones, which are deposited in the bottoms below. In this way the bottom lands have been built up. The loamy character of the soil is due to the process of vigorous washing, which has removed from the soil much of the clay and a considerable part of the iron oxides as well.

These bottom lands are the best general farming lands in the county. Upon them all the grain crops give good returns. The yield per acre of wheat ranges from 12 to 22 bushels, of corn from 30 to 50 bushels, and of hay from 1 to 2 tons. Other crops grown give equally good returns.

The small fruits also do remarkably well on the valley lands. The blackberry, raspberry, currant, and strawberry are chiefly grown and are of excellent quality. The apple orchards are longer lived and yield more heavily on the bottom soil than on the hill soil, but the quality of the fruit is not as good. Among the truck crops the sweet potato is found to produce very well.

With proper attention given to cultivation and rotation of crops the fertility of this soil may be maintained or even increased, and profitable crops of grain and truck obtained year after year.

The table on the following page gives the mechanical analyses of soil and subsoil of this soil type.

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Mechanical analyses of Clarksville loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7614	¼ mile N. of Pottersville.	Brown silty loam, 0 to 12 inches.	1.80	0.46	0.82	1.58	5.72	5.80	71.36	14.24
7616	1 mile E. of Willowsprings.	Brown silty loam, 0 to 10 inches.	2.18	.12	.30	.48	2.90	4.42	75.02	15.08
7618	1 mile E. of Westplains.	Brown silty loam, 0 to 12 inches.	2.07	.08	.56	.56	2.58	3.76	73.22	18.56
7619	Subsoil of 7618......	Yellow heavy silty loam, 12 to 36 inches.	.69	.08	.40	.82	2.88	3.50	70.10	21.84
7615	Subsoil of 7614......	Yellow silty loam, 12 to 34 inches.	.56	.70	1.46	1.84	4.70	5.00	63.36	22.94
7617	Subsoil of 7616......	Yellow silty loam, 10 to 36 inches.	.50	.12	.18	.16	1.20	3.74	69.42	25.04

AGRICULTURAL METHODS.

The agricultural methods of the area have, in a way, been developed by the peculiar local conditions. The presence of large quantities of stone in the soil renders necessary certain modifications of the methods familiar to farmers in regions where the soils are free from stone. Over much of the area some implements, for instance the disk harrow, are almost useless. Frequently in stony land it is found that a sort of mole plow is more satisfactory than the turning plow, since it keeps the rocks on the surface and prevents the fine earth from being washed away. Farming in southern Missouri is not on an extensive scale. The fields are usually small and the implements in use limited in number and variety. Some of the implements are even primitive. Farm machinery does not find a large use and there is a tendency toward the using of small implements, probably justified to some extent by the irregular surface. In cultivation there is need of running the turning plow deeper and the surface implements more frequently, to deepen the soil and conserve moisture, the lack of which is one of the serious hindrances to grain farming in the upland or, in fact, anywhere in the area.

There is a general lack of systematic rotation of crops, which tends to the deterioration of the soils and the impoverishment of the farmer. Clover and cowpeas are grown in every part of the county to some extent, but their growth should be more general, and in addition every other legume that can be turned to use should be sown. The soils as a whole are markedly deficient in organic matter, which is probably

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accounted for in part by the annual fires that swept the country in pre-farming days, destroying the prairie grass and forest leaves. Every application of barnyard manure gives phenomenal returns, and commercial fertilizers—complete mixtures—are also very satisfactory in their results. The use of commercial fertilizers in connection with clover or some other legume and the application of organic matter to the soil in every possible way can not be urged too strongly upon the farmers of the area.

The present system of farming should be modified so that as little bulk of product as possible will be removed from the land. To do this there must be concentration of the output into a form that is more valuable. The chief objection made to stock raising is that the soil will not produce sufficient feed. Certain it is that it will not produce the quantity, acre for acre, that the soils of northern Missouri or the Illinois prairie soils do. But will it not yield forage for half as many cattle per acre; will there not be an annual increase in its productive power under proper management? Continuous grain cropping does not give large returns, either, and each year these grow a little less. It is the conviction of the writer that animal husbandry will ultimately be found to be the most satisfactory form of farming in the area, on the lands that are sown to any of the grain or forage crops.

In orcharding, too, the methods have been developed somewhat by the soil conditions. The most satisfactory surface work in the orchard is accomplished with the ordinary cultivator. In the young orchards the best fruit growers sow cowpeas and rye to serve as feeders to the young trees and help keep down weeds. The amount of cultivation given the trees is made dependent upon the size of the fruit crop. The orchards are considered to need less frequent cultivation during seasons when there is no crop on the trees than when the limbs hang heavy with fruit. One grower reports that by frequent cultivation during the ripening period he was able to retard the maturing of his crop of peaches nearly two weeks, thus securing larger fruit and avoiding to some extent an overstocked market. While there are in the county several orchards that receive very good care generally and quite thorough cultivation, there are very many in which this is not the case. Many of them are neglected in every respect. As a result it is not unusual to see orchards with half the trees dead or dying and the rest lacking in vigor and giving little, if any, returns. In these the grass and weeds have formed a thick sod. It is obvious that if success is to be attained in any form of fruit growing there must be a reasonable amount of attention bestowed on every operation, from planting the trees to marketing the product. Insect and fungus enemies must be fought and diseased trees destroyed. Fortunately, these pests are not as numerous or destructive as in some other sections of the United States.

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AGRICULTURAL CONDITIONS.

The general appearance of the county, the condition of the farms, the size and construction of the farm buildings, the number and kind of implements, and number and quality of the live stock do not indicate a highly prosperous farming class. Another indication of the unfavorable condition of the community is found in the large number of vacant houses and abandoned farms seen throughout the county. It is said that many of these vacancies were occasioned by the exceptionally severe drought of 1901. There is much of the appearance of the pioneer settlement in every part of the area. Around the towns in the central part of the county and in several of the larger valleys there are some prosperous looking farmhouses, but excepting these the buildings are small and antiquated.

According to the Twelfth Census of the United States, of the total of more than 576,000 acres in Howell County, 417,170 acres are classed as included in farms, of which only 153,701 acres are improved. The number of farms in the county is 3,065, of which 3,030 are improved by buildings. The average size of the farms is 136 acres. The average value of the buildings per farm as derived from the same source is $300. The average value of the machinery on the farms is $66 and of live stock $238. The gross receipts from all sources of income except live stock are $295 per farm, and the expenditures for labor $32. The farms are mainly operated by the owners, and the above figures indicate that, while the farms are not large, the cultivated portion is very much smaller and the work is nearly all performed by the operator and his family.

The area of 159,000 acres not included in farms is owned largely by mining companies and by individuals for speculative purposes and lies in the virgin forest. Much of this land is suitable for cultivation.

In the fruit industry the conditions average better than in general farming. The owners of several of the largest orchards reside outside the county and operate their orchards through a resident manager.

No figures are at hand showing the acreage or production of the several fruits. In the county there are between 10,000 and 20,000 acres in orchards, by far the greater area of which is devoted to peaches and apples. The growers rely on a full crop of peaches every third year. The yield of apples is more certain year by year. Some growers contend, however, that growing peaches is the more profitable. The rough, rocky slopes of the Clarksville stony loam areas produce peaches of the largest size and finest quality. The apple orchards do best on the lowest part of the slope and give the largest quantity of fruit per tree, but the largest fruit, and the finest in quality, is obtained on the highest parts of the hills.

The Kieffer pear grows well, and plums bear remarkably well, but neither of these fruits is extensively grown. Grapes of all kinds

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flourish on the upland soils and are said to be more certain than any of the tree fruits. Table grapes—such as the Concord—are, however, quite subject to the black rot, which seriously interferes with their profitable production. Fortunately a number of varieties of the best wine grapes are more resistant to this fungous disease. A single strong stock will produce from 10 to 20 pounds of fruit. An acre set to Moore's Early is reported to have yielded 6,400 pounds of fruit in a single season.

The roads of the county, which are not laid out on the rectangular system, are generally poor, and the transportation of products to the point of shipment is often extremely difficult. But few county roads traverse the area away from Westplains, and even near that town very little work has been done to permanently improve these main highways. The secondary roads—"country roads" as they are called locally—reach all parts of the area. These roads are in reality private, traversing private property, although not closed by gates or fences.

The Kansas City, Fort Scott and Memphis Railroad is the only line in the county. It passes diagonally from northwest to southeast through the center of the county, touching Willowsprings and Westplains. At Willowsprings the Current River branch leaves the main stem, traversing the county in an easterly direction and connecting with the Iron Mountain line at Williamsville. On the main line there are through-train connections with Kansas City and Memphis, but for points northeast the connections are by a rather roundabout route for shipping. There is need of competitive rates to reduce the cost of freight transportation. Surveys which are being made by the Rock Island Railroad Company for a new road give some hope for improvement in this respect.

The local markets for produce are small, and staples of every kind must largely seek outside markets. The large cities are a considerable distance away. Cattle go direct to the slaughtering pens of Kansas City. The fruit is shipped to many parts of the country, some shipments being billed direct to Boston and other Eastern cities.

The condition of the area with regard to markets and transportation is added argument for concentration of the products into the smallest and most valuable form and the retention of cheap, bulky products and waste material on the land. It does not follow because of the present low average income of the farms that the country is naturally poorly adapted to all forms of agriculture. On the contrary, it is capable of giving very fair returns for the labor and capital bestowed upon it. Live-stock production and fruit growing are the interests best suited to the area. These will prove the most profitable, and with the adoption of more intensive methods the average return per farm will be materially increased.

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SOIL SURVEY OF THE STUTTGART AREA, ARKANSAS.

By J. E. LAPHAM.

LOCATION AND BOUNDARIES OF THE AREA.

Arkansas County is situated in the southeastern part of Arkansas and is the third largest county in the State, containing 1,062 square miles. It is bounded on the north by Prairie County; on the east and southeast White River separates it from Monroe and Desha counties, its southeastern corner approaching within 6 miles of the Mississippi

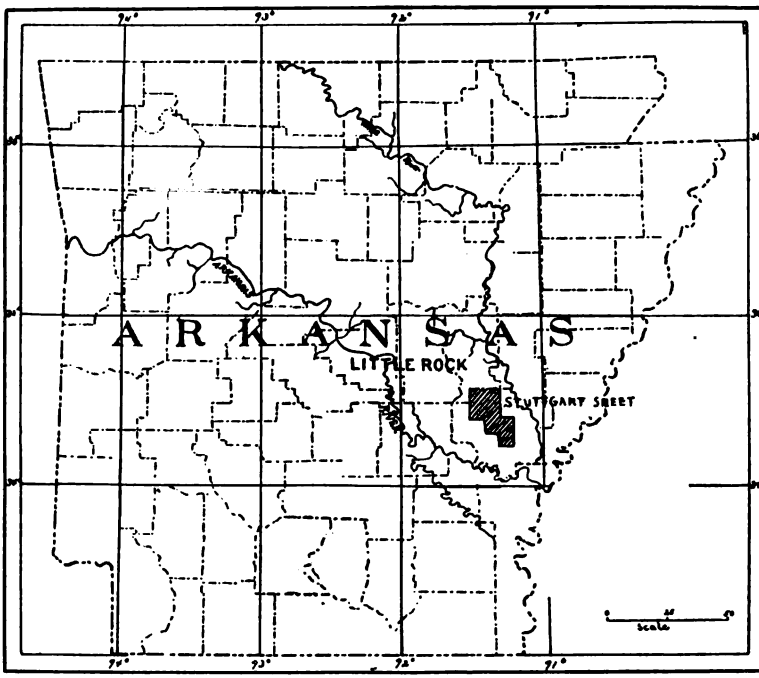

FIG. 17.—Sketch map showing area surveyed in Arkansas.

River near its junction with the Arkansas; the Arkansas River divides it from Desha County on the south, and on the west it is bounded by Jefferson County. It lies approximately between 91° and 91° 35′ west longitude and 34° and 34° 35′ north latitude. The area surveyed lies wholly within the county and comprises 251 square miles, commencing in the northwest part of the county and extending in a southeasterly direction, and including the towns of Stuttgart, Dewitt, and Almyra. Dewitt, with a population of less than 500, is the county seat, and Stuttgart, on the main line of the Cotton Belt Railway, has a population of about 1,200.

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It is thought that the area surveyed includes all the different soil types of the county, with the exception of some alluvial types along the Arkansas River.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Arkansas, in common with many other States of the Mississippi Valley, claims De Soto as her first white visitor. This explorer crossed the Mississippi River into the State somewhere between Memphis and the mouth of the Arkansas River in 1541. It is recorded that he found the Indians living in houses and practicing a rude agriculture. In 1673 Marquette, on his way down the Mississippi, visited an Indian town called Akansea, at the mouth of the Arkansas River. These Indians lived in bark-roofed cabins, harvested corn, and served their meats in dishes. From the fact that some of the cabins were built upon "made hills" their relation to the Mound Builders is argued by some historians.

A few of the companions of La Salle, under the leadership of Chevalier de Tonti, established the first settlement, Arkansas Post, in 1686. Arkansas Post, situated in Arkansas County, on the Arkansas River, was the first settlement made by white men west of the Mississippi River. De Tonti took a great deal of interest in the settlement and early caused French missionaries to be sent there. Regular religious services were held in the wilderness for a number of years, and the Indians were taught improved methods of agriculture. By the treaty of Paris (1763) Louisiana, of which Arkansas was a part, was ceded to Spain, and the new settlement was maintained by the Spanish as a military post until 1800. In 1785 the district of Arkansas contained 196 white inhabitants, and at the time of the Louisiana purchase the population had reached 600. In 1805, two years after the acquisition of the territory by the United States, Louisiana was divided into the Territory of Louisiana and the district of New Madrid, the latter comprising what is now Arkansas and the southern part of Missouri. The district of New Madrid was redivided the following year and the district of Arkansas created. In 1812, when lower Louisiana was admitted to the Union as a State and the Territory of Missouri established, the district of Arkansas, for administrative purposes, remained as formerly, with Arkansas Post as the seat of justice. This district was then nearly as large as the present State of Arkansas. The Territorial organization of Arkansas was effected in 1819, and Arkansas Post, then containing 30 or 40 houses, was continued as the capital. In 1821 the capital of the new Territory was removed to Little Rock. A retrograde movement then set in about the old historic settlement, and Arkansas Post speedily fell into decay. Until after the close of the civil war few attempts were made toward the agricultural development of Arkansas County, though large herds of cattle had for some time

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been pastured upon the rich and abundant grasses of the prairies. A few settlers lived in the edge of the timbered lands, where cotton and corn were the principal products. It was not until about 1880 that interest was awakened in the agricultural possibilities and resources of the country and a tide of immigration began to flow in. The settlers came mainly from the Middle West—from Illinois, Wisconsin, Iowa, Indiana, and Ohio. With the advance in price of farm property in these States many who felt the need of larger acreage were attracted to the open and undeveloped prairies of Arkansas County, where range for stock was abundant and where lands could be purchased for from $5 to $10 an acre.

CLIMATE.

The following table gives data of temperature and precipitation at two stations of the Weather Bureau. The records for New Gascony, which lies in the adjoining county, are fragmentary, and it is therefore impossible to compute the mean annuals for this station.

The rainfall is ample in amount and of comparatively uniform distribution among the seasons.

Monthly and annual temperature and precipitation.

Month.	Stuttgart.		New Gascony.	
	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	Inches.	° F.	Inches.
January	42.3	3.32	41.4	6.15
February	43.1	3.82	43.4	3.69
March	52.3	6.79	53.7	5.80
April	63.5	4.69	59.0	3.60
May	70.3	4.38	72.5	4.10
June	77.7	4.38	79.3	....
July	80.7	2.73	....	3.06
August	79.1	3.41	80.5	3.60
September	73.3	2.90	74.8	3.74
October	61.5	2.92	63.8	4.04
November	50.4	4.65	51.1	3.32
December	44.6	4.12	34.3	4.56
Year	60.5	48.11	....	....

From records covering eight years the latest killing frost in spring at New Gascony occurred on April 22, and during nine years the latest at Stuttgart on April 12. At the former station the earliest killing frost in the fall was on October 15, and at the latter October 18. The average date of occurrence is as follows: New Gascony, spring, March 29; fall, October 29; Stuttgart, spring, March 25; fall, November 2. The average length of the growing season for tender vegetation is therefore 214 days and 222 days for the two stations, respectively.

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PHYSIOGRAPHY AND GEOLOGY.

Arkansas County consists of nearly equal areas of prairie and of forest land. The area selected for the soil survey embraces the best developed and most productive of the former, with enough of the latter to give a clear exposition of the soil characteristics and its agricultural importance.

The surface of the area, especially of the prairie sections, is very flat, with a slight fall, scarcely noticeable to the eye, to the south and east. Drainage is sluggish and is accomplished principally by Mill, Little La Grue, and Big La Grue bayous. These streams are dry during a greater part of the year. The lower portion of Big La Grue Bayou (outside the area surveyed) is spring fed and contains some water nearly the year through. There are no springs within the area. The surplus surface water from the prairie sections reaches these bayous through long, narrow, slightly depressed streaks, locally termed "slashes," which in nearly all cases are covered with a low, sparse, scrubby growth of persimmon, sassafras, wild crab, and black-jack and post oak. For two or three months in midsummer they support a luxuriant growth of large and handsome wild hollyhocks. These slashes often extend in a nearly straight (but sometimes curved or sinuous) line for a distance of 1 to 2 miles, while only a few rods in width, and serve to relieve the monotony of an otherwise entirely treeless prairie.

Nearly isolated in the prairie, and connected with the main forest areas only by low, narrow drainage ways, fringed with timber, are so-called islands of timber, as Big Island Timber, Angelico Island, etc. The forests covering these areas are composed of fairly dense growths of post, willow, and black-jack oak and hickory. The surface is generally 2 or 3 feet lower than the surrounding prairie, and is flat and poorly drained.

In the southwestern part of the area, in T. 4 S., R. 3 W., especially near the bayous, the forested surface becomes quite rolling, though never rugged. With the exception of a few flat hilltops the drainage here is very efficient. Along the bayous in this township occur fairly well-defined bottoms, averaging a quarter of a mile in width. These bottoms are usually flat and level, though occasionally an islandlike mound is seen rising a few feet above the general surface and covered by trees preferring a drier soil.

From the great uniformity exhibited throughout the area, both in the nature of the materials and their physiographic characteristics, it is believed that the soils all belong to one formation, and that the deposits embraced in this formation were laid down on the ocean's floor at the time of the submergence of the eastern half of the State under the Eocene-Tertiary sea. Had the materials been deposited in

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streams and subjected to the action of shifting and intermittent currents a greater variety might have been looked for.

No rocks or minerals of any kind are exposed within the area. No soil sections deeper than 3 or 4 feet were seen upon the prairie, these showing a surface covering of rather loose, porous silt, underlain by silt of a more compact nature, interstratified with bands of clay, as described under the head of soils. Almost without exception the wells upon the prairie are driven, no obstruction in the shape of stones or difficultly penetrable material being offered to the passage of the pipe until water is reached in a bed of gravel at a depth of from 90 to 110 feet. An open-well section at Almyra gave much reddish and brown clay, locally called "joint clay," but showed an absence of sand. A 12-foot boring 2 miles southeast of Stuttgart yielded fine reddish sand at 10 feet. Gullies along Little and Big La Grue bayous gave two sections which showed, underlying the reddish clay, interstratified layers of brown clay and sharp reddish sand. The position of these strata was in all cases horizontal.

SOILS.

So far as the texture is concerned great uniformity exists between the different soils of the area, and in physiographic position the types are not greatly dissimilar.

Three types have been recognized, viz, Miami clay loam, Almyra silt loam, and Guthrie clay.

Areas of different soils.

Soil.	Acres.	Per cent.
Miami clay loam	69,696	43.3
Almyra silt loam	63,104	39.3
Guthrie clay	27,904	17.4
Total	160,704	

MIAMI CLAY LOAM.

The Miami clay loam is a reddish-yellow loam containing considerable silt and clay and having a depth of about 10 inches. It is mellow, friable, and of fine tilth. The subsoil is a reddish-yellow to grayish-yellow silty clay, more or less mottled and somewhat waxy and plastic. When wet this clay is very sticky, but it dries readily and gives little trouble in cultivation. The texture of both soil and subsoil is very much more uniform than in the case of the other types of the area. The subsoil was examined to a depth of 36 inches.

This soil is found scattered about throughout the prairie section of the area wherever the drainage is most efficient. It is best developed, and to the greatest extent, in the northern and northwestern part of the area, becoming less connected and more irregular in outline to the

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southward. In sec. 20, T. 2 S., R. 5 W., and on the road between section 31 of the same township and section 6 of the adjoining township, south, are small areas of fine sandy loam which together amount to only half a square mile. As it was not thought desirable to establish a separate type for these small areas they were included with the Miami clay loam. They occur in small ridges only slightly higher than the surrounding type. There is a woodland phase of the type most typically developed in T. 4 S., R. 3 W. In T. 3 S., R. 4 W., a strip is found extending parallel with and on each side of Mill Bayou.

The Miami clay loam occupies the highest portions of the prairie. Small detached areas of it sometimes occur along the slopes leading from the flat, poorly drained uplands to the "slashes" or natural drainage ways.

While much of the unwooded area covered by this soil appears to the eye to be quite level and flat, there is just enough fall to carry off surplus surface water. The forested area is as a rule more rolling. The soil is naturally rather porous, and except in times of excessive rainfall the drainage is adequate.

The principal crops grown are oats, averaging from 30 to 50 or more bushels to the acre; corn, which gives a yield of from 25 to 40 bushels, and cotton, averaging about one-half bale to the acre. Broom corn in some instances does fairly well, though very often badly choked by crab grass. Very little wheat is grown, though a yield of about 25 bushels is secured where the crop has been tried. Vegetables are grown for home use, and nearly all varieties do well. The usual orchard fruits are successfully grown, especially apples, peaches, plums, and apricots.

This type of soil is quite well adapted to the production of the cereals. Among them oats seem to be a prime favorite and give prolific yields. The native grasses, from long pasturage and cutting, are beginning to fail, and it is believed that some of the tame grasses could be successfully substituted. Tobacco has been grown only in a small way for home consumption, but it is thought that this industry might be profitably introduced. Small areas of different types of leaf should be tried experimentally to learn the one best adapted to the soil and climatic conditions.

The table on the following page shows the mechanical analyses of typical samples of the soil and subsoil of this type.

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Mechanical analyses of Miami clay loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7487	SW. ¼ sec. 8, T. 2 S., R. 5 W.	Loose silt, 0 to 14 inches.	1.28	1.04	1.54	0.44	1.44	11.58	73.36	9.92
7483	1¼ miles SW. of Stuttgart.	Yellowish-brown silt, 0 to 12 inches.	2.19	.74	1.04	.44	4.84	17.54	63.24	11.66
7477	NE. ¼ sec. 17, T. 3 S., R. 4 W.	Reddish-brown loam, 0 to 12 inches.	2.20	.10	.78	.58	1.26	4.16	80.00	12.76
7488	Subsoil of 7487	Friable silt, 14 to 30 inches.	.67	.44	2.28	1.38	2.48	10.28	72.94	9.52
7484	Subsoil of 7483	Yellow silt, 12 to 32 inches.	.58	.14	.76	.54	4.14	14.40	60.58	18.46
7478	Subsoil of 7477	Silty clay loam, 12 to 36 inches.	.69	.62	1.10	.54	.66	1.04	68.76	26.52

ALMYRA SILT LOAM.

The Almyra silt loam is a rather loose, silty loam of the same general texture as the Miami clay loam. In color it is a mottled grayish brown to a depth of 10 or 12 inches. From 12 to 18 inches the subsoil is lighter in color, a mottled gray and yellow, usually stained with iron, and contains a few iron concretions from one-eighth to three-eighths inch in diameter. From 18 to 24 inches a whitish stratum of silt appears, grading at the lower depth into reddish-brown clay. This clay contains a considerable amount of silt and, while not appearing very compact or tenacious in sections seen in road cuts, is still quite impervious to water. The general relations of the soil and subsoil are similar to those of the Miami clay loam, except that the successive changes in texture are found nearer the surface.

The type is found best developed over an area commencing to the south of Stuttgart and extending southeast to the boundary of the area surveyed.

The surface of this soil is nearly level. Usually the areas occupy depressions in the prairie upland, although they also occur along the borders of the lower, timbered lands, where the prairie is generally low and flat and where drainage is sluggish. The type sometimes continues for a little way into the edge of the timber, or it may be that the scrubby growth of black-jack and post oak has encroached upon the prairie from the woodland. Otherwise it is covered with a rather coarse growth of prairie grasses and has no natural forest growth.

Deficiency in drainage seems to have been the principal factor in separating this type from the contiguous one, the Miami clay loam,

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and it is believed that thorough surface and under drainage, together with aeration of the soil by deep subsoiling, would soon modify the wet, crawfishy conditions of the Almyra silt loam and produce a soil similar to the type first described. During heavy rains the inability of the flat, poorly established natural drainage channels to quickly dispose of the surplus water leaves great quantities standing upon the surface, a relatively large proportion of which remains until removed by the process of evaporation. The establishment of an adequate system of surface county drains and the tiling of the fields is a work which can not be too strongly urged and one which will repay a considerable money outlay.

Only a small percentage of the area covered by this type is in cultivation, but when the season is not too wet to allow proper tillage good yields of oats, corn, cowpeas, sorghum, and Kafir corn are secured. Cowpeas seem to do particularly well under favorable conditions. Much of the area is covered with a growth of native grasses, which yield about 3 tons of hay to the acre. These grasses are of rather coarser quality than those grown upon the Miami clay loam.

Under an effective system of drainage this soil no doubt would be adapted to almost any of the usual farm crops. The character of the soil would doubtless be materially benefited by the intelligent application of lime. The soil is in many instances slightly acid, and this condition would be ameliorated by the lime. At present its principal value is for hay and pasturage, as, except in dry seasons, tillage is difficult and crops requiring a well-drained soil are uncertain.

The following table shows the mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Almyra silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7471	E. ½ sec. 22, T. 3 S., ½ R. 4 W.	Brown silty loam, 0 to 12 inches.	2.04	0.50	0.50	0.12	0.18	3.72	80.14	14.78
7467	3 miles S. of Dewitt.	Silty loam, 0 to 10 inches.	1.98	1.62	2.34	.54	.46	1.12	77.42	16.26
7469	¾ mile E. of Stuttgart.	Brown silt, 0 to 12 inches.	2.36	.02	.24	.18	.90	6.60	74.92	16.84
7470	Subsoil of 7469	Gray silt, 12 to 30 inches.	.91	.18	.66	.30	.52	5.54	78.52	14.14
7472	Subsoil of 7471	Silty clay, 12 to 36 inches.	.50	.20	.62	.26	.48	2.82	74.46	20.78
7468	Subsoil of 7467	Gray to yellowish-gray silt, 10 to 24 inches.	.98	1.68	2.54	.56	.48	1.18	72.10	21.42

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GUTHRIE CLAY.

To a depth of about 14 inches the Guthrie clay is a grayish-white silt occasionally mottled with yellow and containing some clay. It is acid to the taste, chalky to the touch, and frequently contains small iron concretions. The subsoil is about the same in color, mottled with yellow and brown iron stains. Below 24 inches, and extending to 36 inches, there is a mottled-gray and yellowish-brown clayey silt, which, however, is not very tenacious, and is fairly readily crumbled. While loose in structure, this material is impervious to water and remains wet nearly the whole year through.

This soil is found in the low, poorly drained woodlands in the northern part of the area and along the courses of the various streams and bayous. The largest areas of it occur in T. 2 S., R. 4 W., while areas several square miles in extent are found in what is known as Big Island Timber, to the northeast of Stuttgart. It is well developed also in the "slashes" or drainage depressions connecting the prairies with the woodlands.

The Guthrie clay occupies only the lowest positions, where the drainage is exceedingly sluggish or where there is no drainage at all. Much of the bayou bottoms, which remain forested, is included in this type, and it is occasionally found occupying flat hilltops in the timbered upland areas. Along the "slashes" leading from the prairies to the woodlands it is covered with a scrubby growth of persimmon, sassafras, wild crab, black-jack oak, and post oak. In the areas of larger extent the forest growth comprises more species and the trees grow to a considerable size. They embrace post, red, Spanish, pin, overcup, back-jack, willow, and water oak. The last two species, together with three or four varieties of hickory, are the most characteristic trees growing upon this type of soil. Elm and sweet and black gum are commonly seen, and along the course of Big La Grue Bayou are some fine specimens of the "cow" oak.

Because of lack of drainage the Guthrie clay has no agricultural value. A part of it is susceptible of drainage, notably the bottoms along Little and Big La Grue bayous, the most promising areas of the type.

The soil is derived from old sedimentary deposits, and those areas of it which lie along streams are sometimes modified to a slight extent by more recent depositions of silt.

The Guthrie clay in the Stuttgart area is not cultivated, nor is it likely soon to be, except possibly in the areas along the bayous, which are so situated as to be readily drained. These have not as yet been cleared of the original forests.

The table on the following page shows the mechanical analyses of typical samples of the soil and subsoil of this type.

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Mechanical analyses of Guthrie clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7481	S.E. ¼ sec. 17, T. 3 S., R. 4 W.	Dark silt, 0 to 14 inches.	1.24	0.06	0.34	0.14	0.70	10.22	69.94	17.76
7479	¼ mile E. of Stuttgart.	Light gray silt, 0 to 12 inches.	1.19	.08	.14	.18	.48	6.34	73.68	18.76
7482	Subsoil of 7481......	Gray clayey silt, 14 to 36 inches.	1.00	.16	.44	.42	1.56	13.48	63.66	19.56
7480	Subsoil of 7479......	Light gray silt, 12 to 32 inches.	.68	.14	.14	.16	.26	5.82	66.76	25.90

AGRICULTURAL CONDITIONS.

There are no large towns in Arkansas County, the largest, Stuttgart, containing only about 1,200 inhabitants, so that the population of the county is mainly agricultural. A large proportion of the farming class, especially of those settled upon the prairies, came from the Northern States, where economic and agricultural conditions differ widely from the local conditions. It is not surprising that after but a few years' residence in a country to the climatic, agricultural, and economic conditions of which they are unaccustomed a few should become dissatisfied and wish to return. A considerable number have done so, but the majority of those who have become acclimated, and have lived in the country long enough to learn by experiment the methods of agriculture best adapted to the new conditions, have prospered and have come to like the country of their adoption. The failure of some who move to the county is due to the fact that too much of their savings is invested in land and too little is left available to properly equip a farm with stock, tools, etc., and to insure a living until a few crops shall have been harvested.

Most of the farms are owned by the farmers, though a few are rented from owners living in the Northern and Eastern States. The money rental asked for well-improved farms is on an average from $2 to $3 an acre; the crop rental received from a tenant is usually about one-third.

The majority of the farms were originally Government or State lands, and were either sold or disposed of as homestead grants and "donations" in quarter sections of 160 acres. Though quite a number of larger holdings exist, especially in the case of prairie cattle ranges, 160 acres is about the average size of the farms throughout the area surveyed.

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The majority of the laborers, except in the timbered areas where cotton is raised, are white, almost no colored laborers being employed upon the prairie farms. White laborers are fairly abundant and command a wage of about $15 a month with board. Few farmers require hired help, except through the busier seasons of the year.

Not much diversity exists in the agricultural products of the county. One of the principal industries is the raising and fattening of cattle for market. The abundance and luxuriance of the native grasses and the ease with which stock can be carried through the mild winters have made this one of the most profitable investments. The improvement of stock has received comparatively little attention, and, with the exception of a few thoroughbred and grade Herefords, the cattle are mostly "scrubs." One fairly well patronized creamery exists in the area, but as a rule there is very little dairying carried on. A few sheep and goats are seen, but they are not raised to any considerable extent. There is a good demand in the area for hogs for home consumption, and the supply is greatly deficient. Few except of mongrel breed are seen. The facility with which corn and cowpeas can be grown and the abundance of acorns and other mast in the timbered areas should make pork production a remunerative industry.

Besides the extensive areas of prairie grasses used for pasturage a large amount of wild hay is cut, baled, and shipped to different parts of the country. The cutting continues throughout the summer and into the autumn, two or three crops being harvested. The first cutting averages about 3 tons to the acre, the later cuttings being inferior in yield and quality. The grass consists principally of blue stem, much of which is coarse and unattractive, yet it seems to be relished by stock, and is consumed with very little waste. The price paid for hay delivered on cars at the time of cutting is from $3 to $4 a ton; in the winter it often brings from $7 to $9.

Among the cultivated crops a very large acreage is devoted to winter oats. Oats of fine quality, well-filled grains, and prolific yield are secured. Wheat is grown to only a very limited extent, while corn yields well and finds favor as a farm crop. Kafir corn, sorghum, Irish and sweet potatoes, general orchard fruits (except cherries), melons, many of the berries, and most of the vegetables are the principal other products.

There is such similarity between the soils of the area that, provided the moisture conditions are the same (brought about through drainage, or as affected by varying seasons), crops show little preference for one over either of the other two arable types. The culture of cotton is confined almost exclusively to the timbered lands, though in the one or two instances where it was seen growing upon the prairie the growth was noticed to be luxuriant. Perhaps one reason for the absence of cotton upon the prairie is the fact that the farmers there

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are nearly all Northern men, who have no knowledge of and no desire to cultivate the crop.

Railroad transportation is furnished by the St. Louis Southwestern Railway, the main line of which passes through the northern part of the area in a southwesterly direction. Its length within the area is about 10 miles. The Stuttgart branch passes through about 30 miles of the area, from Stuttgart in a southeasterly direction. In the area surveyed the farthest point from a railroad station is about 8 miles. Transportation in the extreme southern part of the county can be had by the Arkansas River, which is navigable at all seasons of the year. White River, at the eastern boundary of the county, is also a navigable stream.

The wagon roads are very good during most of the year. They follow section lines, except in some cases in the timbered areas, and are maintained by a special tax levied for the purpose. During heavy rains and sometimes for a day or two thereafter there is considerable standing water upon the roads across the more level portions of the prairies, but they dry quickly and soon become firm and compact. There are no toll roads in the area surveyed.

The principal local market is Stuttgart, whence such produce as is not consumed there is sent to various northern and eastern points. The distance to Memphis is about 120 miles, and by rail to Little Rock it is somewhat less. These two cities, together with Pine Bluff, are the most easily reached of the near-by markets.

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SOIL SURVEY OF THE WICHITA AREA, KANSAS.

By J. E. LAPHAM and B. A. OLSHAUSEN.

LOCATION AND BOUNDARIES OF THE AREA.

The area surveyed in Kansas comprises the southern half of the Wichita sheet, United States Geological Survey, and lies between the parallels of 37° 30′ and 37° 45′ north latitude and the meridians 97° and 97° 30′ west longitude. It includes approximately 320 square miles in the southern part of Sedgwick County and 145 square miles in southwestern Butler County. Sedgwick County lies a little to the

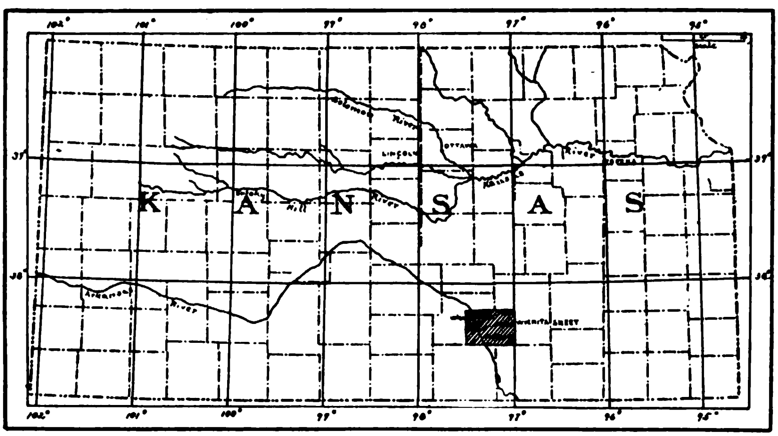

FIG. 18.—Sketch map showing area surveyed in Kansas.

east of a line drawn from north to south through the center of Kansas, and the southern limits of the area surveyed reach to within about 35 miles of the Oklahoma line. Wichita, the county seat of Sedgwick County, is the third city in size in the State and has a population of about 25,000. It has exceptionally good railroad facilities, and geographically is advantageously situated, standing as it does at the gateway to the rich agricultural districts of Oklahoma, Indian Territory, and northern Texas, the resources of which are only beginning to be realized.

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HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Probably the first white men to visit Kansas were Coronado and his adventurous band of Spanish gold seekers, who entered the State in 1541 and laid claim to the country by right of discovery. In 1682, ignoring the prior rights of Spain, the French flag was planted by La Salle at the mouth of the Mississippi River and the country named Louisiana. New Orleans became the French capital in 1718, and in 1722 the French established a fort on the Missouri River at the mouth of the Osage. In 1762 Louisiana was ceded by France to Spain, and in 1800 retroceded by Spain to France. The purchase from France of the Louisiana strip, which included all but a portion of southwestern Kansas, was made by the United States in 1803. The exploration of the newly acquired territory was immediately begun. The expedition of Lewis and Clark was started in 1804, followed in 1806 by that of Lieutenant Pike. In 1816, as commander of the United States topographical engineers, Major Long commenced an exploration lasting eight years. The great Santa Fe trail, over 700 miles long, was established about this time, and for many years continued to be the only avenue of commerce across the Great Plains. The first railroad to cross Kansas from east to west was the Union Pacific, which reached Denver in 1870. This was closely followed by the Santa Fe Railroad.

At the time of the purchase by the United States of the territory known as Louisiana there were four principal tribes of Indians living in it—the Osage, the Kansas or Kaw, the Pawnee, and the Padoucas. These tribes occupied lands in the eastern part of Kansas and in Missouri. The early boundaries of the Indian Territory, surveyed in 1830, included the greater part of the State of Kansas, and into this territory the removal of the Indians had begun as early as 1824. The lands in the vicinity of Wichita were used as a hunting ground by the Osage tribe, but they practiced little or no agriculture in that part of Kansas. In 1863, consequent upon the disturbances of the civil war, the Wichita were driven from their more southern territory and camped near the present site of Wichita, at the junction of the Arkansas and the Little Arkansas Rivers, where they engaged in agricultural pursuits of a primitive nature until 1867, when they returned south. At that time buffalo roamed the plains in vast numbers, and as early as 1860 a few pioneers came into the country and engaged in the fur trade with the Indians. The first of these to become a permanent resident of Sedgwick County was Hon. J. R. Mead, who went to Wichita in 1863. In 1867 a strip of territory which included Sedgwick County was opened for settlement, but it was not until the next year that the real agricultural development began. In this year several pioneers bought lands along the streams and engaged in general farming, while others, taking advantage of the rich natural

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grasses of the prairie, turned their attention to cattle raising. Sedgwick County was organized in 1870, and from this time on many settlers were attracted to the fast developing country. A great many cattle were at this time driven up from Texas through Sedgwick County to Abilene, where they were fattened and shipped to eastern markets. In 1872 a branch of the Santa Fe Railroad was completed from Newton to Wichita, and for several years thereafter the latter city was the shipping point for thousands of head of cattle driven up from the ranges of the Southwest.

The principal products of Kansas have always been corn, wheat, and cattle, and from the earliest settlement of the country it is to these staples that the attention of the farmers of Sedgwick and Butler counties has been turned. Nearly all the fruits and vegetables have from the first been grown for home consumption, though little attention was formerly paid to their shipment to other markets. Despite the great fertility of the soils, the history of the early agriculturist has not been one of uninterrupted prosperity. Considerable hardship has at times been entailed by reason of severe droughts, and the settler has suffered greatly in former times from the visitations of grasshoppers. Education has received special attention from the beginning of Kansas history, and the facilities afforded in the primary schools and institutions of higher learning are excelled by those of few other States. In the regular attendance at schools, in proportion to the population, Kansas boasts of first position among the States of the Union. Wichita offers abundant facilities for the education of her children, and, besides her ward schools, possesses three or four well-patronized preparatory colleges.

CLIMATE.

The following table, compiled from records of the Weather Bureau stations at Wichita and Mounthope, shows the normal temperature and precipitation of the area. It will be noticed that the rainfall is heaviest during the growing season, and is usually sufficient for the proper maturing of the crops grown. A marked falling off in the monthly precipitation begins in November and continues through the winter months.

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Normal monthly and annual temperature and precipitation.

Month.	Temperature.		Precipitation.	
	Mount-hope.	Wichita.	Mount-hope. [a]	Wichita.
	°F.	°F.	Inches.	Inches.
January	31.5	32.3	0.20	0.92
February	35.8	32.2	1.38	1.29
March	41.4	44.9	.53	1.87
April	57.1	57.5	4.20	2.95
May	66.5	65.1	1.44	4.27
June	78.7	74.6	1.33	4.97
July	81.3	78.8	1.37	3.21
August	78.4	78.1	1.56	3.02
September	70.9	70.5	4.04	2.91
October	54.8	59.4	4.80	2.40
November	42.1	43.9	.53	1.05
December	35.1	36.6	.38	1.00
Year	58.0	56.2	21.76	29.86

[a] Figures are actual precipitation for the year 1901; normals have not yet been established for this station.

The growing season for tender vegetation covers a period of about one hundred and sixty-five days, the average date of the last killing frost in spring occurring in the latter part of April and the earliest in fall between the 1st and 15th of October.

As stated, the figures given in the table of temperature and precipitation are normals, with the exception noted, and indicate the average of probabilities. They do not show extremes of temperature nor the periods of severe drought that sometimes occur. The droughts are often accompanied by scorching winds from the more arid country to the west and south, and at such times the crops shrivel in the fields. The frequency and severity of such periods are, of course, greater in the more western part of the State.

PHYSIOGRAPHY AND GEOLOGY.

The area embraced in the Wichita sheet lies at an elevation of from 1,250 to 1,400 feet above sea level, and in topography is a rolling prairie, the otherwise treeless monotony of which is relieved by the presence along the few shallow streams of a moderately thick growth of cottonwood, walnut, and a few other indigenous trees. The greater portion of the upland is marked by low, smoothly rounded, and gently undulating billowy ridges or crests, the tops of which are scarcely ever more than 20 feet (usually much less) above the troughs of the swells. These swells are from a few hundred yards to half a mile or more apart, usually follow approximately parallel lines, and generally trend in a direction slightly west of north and east of south. This contour more often gives a level sky line looking to the east or west than to the

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north or south. Occasional nearly flat expanses of upland are met covering several square miles, standing in the center of which one is at a loss to determine in which direction the surface slopes. It is one of the peculiar phenomena of the prairie country that no matter where one stands a higher vantage ground appears to lie just beyond, which, when reached, proves to have no greater elevation than the previous station. A somewhat peculiar sensation is experienced upon finding oneself standing in the bottom of a shallow, amphitheaterlike depression, the descent into which has been so gradual as not to have been appreciated, and to suddenly find the distant view cut off on two or three sides by a rim of the prairie which forms the sky line a half mile to a mile distant.

A prominent feature of the physiography is the Arkansas River Valley, which crosses the western part of the area in a general south-southeasterly direction. It ranges from 4 to 6½ miles in width, and comprises about 85 square miles of land surface. The present river channel is from 100 to 200 yards wide, and through the loose, constantly shifting sands of this river bed the stream, some 25 to 50 yards in width, threads its way. The river at its normal level is very shallow, and it is only when reenforced by local rains or by freshets due to rains and melting snows at its Colorado source that it occupies the full width of the channel. It occasionally then overflows its banks and extends to some distance into the valley beyond. Much less water is said to come down the Arkansas than formerly, the loss being due in part, no doubt, to the extensive irrigation at present practiced in eastern Colorado. The valley reaches its greatest width (6½ miles) in the northern part of the area. The western border of it is characterized by the presence of loose sands, the well-rounded grains of which consist of quartz and feldspar. Part of this material has been transported from the upper reaches of the river, and perhaps some of it has come from the near-by Tertiary deposits of the uplands, which in the northern part of the area form a low, well-defined escarpment extending for a few miles along the valley plain. Farther to the south this escarpment in many places becomes obliterated and the junction of the upland with the valley is not well defined. The topography of that part of the river valley covered by the heavier soils is quite flat, but the sands are often drifted into low dunes of from 2 to 6 feet in height. Dunes in the process of rapid formation are often seen on the leeward side of the osage-orange hedges.

The Little Arkansas River, rising about 80 miles north and emptying into the "Big" River at Wichita, substantially increases the volume of the larger stream. Were it not for this accession there would be little water in the main channel during the drier portions of the year.

Besides the two streams mentioned, the area is watered and drained by Cowskin Creek, a small, sluggish stream lying to the west of and

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flowing nearly parallel to the Arkansas River, of which it is a tributary. The Walnut River and its tributaries, Fourmile and Eightmile creeks, together with the Whitewater River, drain the eastern half of the area, the watershed between the Arkansas and the Walnut River lying about 6 miles to the east of the former. Tributary to these principal smaller streams are a number of "draws," or shallow ravines, which furnish immediate drainage to the uplands. The Walnut River is quite an important stream, and in the vicinity of Douglass has eroded a valley from 1 to 2 miles wide, with the formation in the area of from 10 to 12 square miles of rich alluvial soil. The west bank of this stream is formed by bluffs of partially degraded limestone, rising to the height of about 75 feet from the river level. Nearly all of the bottom land lies on the east side of the river.

The results of the geological studies and investigations of Hay, Prosser, Haworth, and others show the Permian or Permo-Carboniferous to be the most extensive and important formation in the area. The bed rock is quite thickly covered with residual soil, modified in some localities by later deposits, but outcrops in the neighborhood of Douglass and along the eastern border of the area show it to consist of rather soft yellowish to grayish limestone, interbedded with usually light-colored shales. In this locality considerable quantities of chert are included in the limestone. The influence of this chert is manifested in the topography of the country, where, in a few instances, small knobs of it are left elevated above the level of the surrounding plain. On the west bank of the Walnut, 4 miles north of Douglass, are a few small, buttelike mounds rising abruptly above the surrounding hills. These are composed of a yellowish-brown crystalline limestone which has resisted the agencies of weathering to a greater extent than the remainder of the rock. The rock is quarried to some extent, and furnishes a fair grade of building stone. There are limestone outcrops also at a few points to the east, and in the near vicinity of Wichita, but these are not prominent, while on the west side of the Arkansas River this formation is so far weathered that the rocks are seen in place in but one or two localities, notably along Spring Creek. Two of the loams of the area are derived from the weathering of this limestone formation, and it is probable that one of the other loams is modified by it. The main type, Sedgwick clay loam, seems to be produced directly from its degradation.

On the west side of the Arkansas River Valley, especially in the northern part of the area, unconsolidated material referred to the Tertiary era is found to be extensive. This material ranges in consistency from a clayey sand to a sandy clay. The sand runs from fine to coarse in texture, is red in color, and consists mainly of grains of feldspar and quartz. A boring occasionally shows a coarser textured sand, grading into a fine gravel, grayish in color, and sticky with a cement of lime. The actual contact between this Tertiary formation

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and the Permian was discovered in but one or two places. In section 17, Ohio Township, calcareous shales are exposed along Spring Creek, and in one of the draws about 2 miles to the east of this exposure shale is also seen. An outlier of the tertiary is encountered in the vicinity of Fairmount College, east of Wichita. This also rests upon the Permian. In a cut on the Frisco Railroad, in this locality, are seen masses of pure white lime deposit of chalky consistency. This material is also encountered in borings in the vicinity.

Along the Arkansas River, south of Wichita, in the townships of Gypsum and Rockford, well-defined exposures of loess are seen. In sec. 10, R. 1 E., Gypsum Township, this silty material overlies shale and a coarse, highly calcareous, light-gray sandstone. The loess at this point is about 20 feet thick. South of Derby, at the extreme edge of the map, it attains a thickness of about 40 feet. The most easterly exposure of the loess discovered is along Spring Creek, 3 miles northeast of Derby. The material here contains scattered lumps of crystallized gypsum and overlies limestone of an evident mud-flat formation. The loess is heavy in texture, and the soil which it forms so closely resembles the residual soil of the limestone that its influence is not perceptible for a much greater distance than 3 miles from the river.

A few exposures of a dark, slaty gray impure gypsum are found on the upland a few miles east of Wichita. The water from the wells in this locality is in some instances so strongly impregnated with it as to be unfit for domestic use. This mineral is not present to such an extent, however, as to greatly influence the soils.

SOILS.

Nine soil types have been recognized and mapped in the area. The types are described in the order of their areal importance. Six of the types are found on the upland—Sedgwick clay loam, Derby loam, Sedgwick loam, Clarksville stony loam, Sedgwick black clay loam, Sedgwick sandy loam. The three remaining types which occur in the Arkansas River Valley are the Arkansas loam, Miami sand, and Miami fine sand.

The following table gives the area of each type in acres and the proportion which each forms of the entire area:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Sedgwick clay loam	136,320	45.8	Sedgwick black clay loam	5,568	1.9
Sedgwick loam	47,040	15.8	Clarksville stony loam	4,352	1.5
Arkansas loam	45,568	15.3	Sedgwick sandy loam	3,136	1.0
Derby loam	20,416	6.9	Total	297,536	
Miami sand	19,392	6.5			
Miami fine sand	15,741	5.3			

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SEDGWICK CLAY LOAM.

The Sedgwick clay loam, to an average depth of about 9 inches, consists of a friable silty loam, ranging in color from a chocolate brown to a dark brown. It possesses an even uniform texture, and when rubbed between the fingers feels more clayey than silty. Following rains there is a tendency to the formation of a thin crust at the surface, but this is easily broken and does not offer much resistance to the penetration of the soil by vegetation. When wet the soil is very sticky, and until it has become fairly dry cultivation is difficult, because the tools do not "scour" readily. Clods are also apt to form. The subsoil, to the depth of 18 or 20 inches, grades from a heavy brown clay loam to a dark-brown clay of a cuboidal fracture, sometimes locally called "joint clay." From 20 to 36 inches the subsoil becomes somewhat looser in structure, as well as more silty in texture, a little lighter in color, and occasionally contains a few small concretions of lime. At a depth of 30 to 36 inches the subsoil is at times exceedingly tough, rather dry, and contains a good deal of iron in the shape of small, very dark metallic brown concretions. At this zone the soil grains are, if anything, inclined to be coarser, the toughness being due to the presence of the iron. The subsoil of this type is very variable, however. On the west side of the Arkansas River in some localities it is more or less modified by the later Tertiary deposits, and occasionally contains a very small amount of sand; in the western part of the area, in the vicinity and to the north of Rosehill, while retaining the same characteristic jointed structure, the subsoil is much mottled with a light-drab clay; in Butler County, near the Walnut River, where the parent rock is nearer the surface, both soil and subsoil are lighter and redder in color and the structure of the subsoil slightly looser. These variations have been deemed too slight, however, to warrant making separate soil types of the different phases.

The greatest extent of this soil is found in the eastern third of the area, on a high, rolling prairie. These areas are well drained by a few small streams and the many draws or shallow ravines tributary to them. In only a few instances, on flat hilltops, is artificial drainage necessary. The natural forest is mainly cottonwood, which grows along the banks of the streams.

The soil is derived from the weathering of the carboniferous limestones and shales. It seems well adapted to the production of corn and wheat, the average yields of the former being, one year with another, about 20 bushels; of the latter, 15 bushels per acre. Scattered about over the area several square miles of the natural prairie grasses are still seen growing, which furnish excellent pasturage and a good quality of hay for winter use. The subsoil is rather too heavy for the successful growing of alfalfa, but considerable Kafir corn is

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yearly harvested. Fruit trees show a sturdy growth, and the yield of fruit is abundant, though it is not grown to any extent for market. Nearly all kinds of vegetables yield well and are grown in sufficient quantities for home consumption.

The following table shows the mechanical analyses of the soil and subsoil of three samples of the type:

Mechanical analyses of Sedgwick clay loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6915	N. ½ sec. 27, T. 28 S., R. 1 W.	Dark-brown silty loam, 0 to 11 inches.	2.66	0.36	2.14	2.04	2.90	10.20	74.30	7.94
6917	SW. ¼ sec. 34, T. 28 S., R. 1 W.	Reddish-brown silty loam, 0 to 10 inches.	3.07	.14	1.54	2.32	5.28	10.40	65.78	14.16
6913	SW. ¼ sec. 18, T. 29 S., R. 4 W.	.....do	2.86	.18	.74	.70	1.34	10.28	71.26	15.50
6918	Subsoil of 6917.......	Heavy brown loam to clay loam, 10 to 36 inches.	1.05	.16	.88	.74	1.66	4.94	77.38	14.14
6916	Subsoil of 6915.......	Brown clay loam, 11 to 36 inches.	1.00	.12	2.18	2.00	2.62	6.34	70.12	16.08
6914	Subsoil of 6913.......	Heavy clay loam, 10 to 36 inches.	1.14	.10	.64	.48	1.12	8.80	68.18	20.34

DERBY LOAM.

The surface soil of the Derby loam is a friable, mellow, yellowish-brown to reddish-brown silty loam, containing a very small proportion of very fine sand, and extending to the depth of about 10 inches. It is very uniform in both texture and structure, and grades almost imperceptibly into the underlying subsoil. The subsoil, at a depth of from 10 to 36 inches, contains slightly more fine material and the grains are somewhat more compact in their arrangement. Along Spring Creek, near Derby, a strip of "second bottom" occurs, aggregating a little over a square mile in extent. The soil is here slightly coarser and looser, and has been classed with the Derby loam, as resembling it much more closely than the alluvial type of loam elsewhere described.

The soil is easily cultivated, does not bake or clod, and has excellent drainage. It is an upland soil, and is found typically developed along the east bank of the Arkansas River, south of Wichita. It forms 6.9 per cent of the area. It is derived from the weathering of a fine, compact loess deposit overlying the Permian limestone. Its contact with the residual soil of this limestone, at its eastern boundary, is not sharp, the soils grading almost imperceptibly into each other.

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It is one of the best soils of the area for general agricultural purposes, being excellent wheat and corn land. The average yield of wheat is about 18 bushels, of corn 25 bushels, per acre. With the use of the subsoil plow it is thought that alfalfa might do well.

The following table gives the mechanical analyses of the type:

Mechanical analyses of Derby loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6899	SE. ¼ sec. 1, T. 29 S., R. 2 E.	Yellowish-brown silty loam, 0 to 12 inches.	2.73	0.86	2.00	0.12	5.84	29.18	44.86	17.24
6901	W. ½ sec. 7, T. 28 S., R. 2 E.	Brown silty loam, 0 to 11 inches.	3.16	.70	2.30	2.34	8.70	26.02	39.06	20.64
6900	Subsoil of 6899	Yellowish silty loam, 12 to 36 inches.	1.18	.10	.44	.68	2.26	21.20	58.00	17.30
6902	Subsoil of 6901	Silty loam, 11 to 36 inches.	1.31	.40	3.74	4.68	16.34	20.96	31.28	22.28

SEDGWICK LOAM.

The Sedgwick loam is a fine, mellow reddish-brown loam to a depth of 10 inches. It often contains a small percentage of fine sand. The subsoil consists of a somewhat tough reddish loam, which at from 24 to 36 inches grades into a tenacious red sandy clay, the grains of which are composed mainly of feldspar and quartz. The soil is friable and easily cultivated. The type is principally found in the northwestern part of the area, though a few square miles occur in the southwestern portion. Altogether, it constitutes 15.8 per cent of the area. The topography of this type is that of a slightly rolling prairie, which in general is very well drained. Little artificial drainage is required. The soil is derived from an unconsolidated material, consisting of clay and sand, of Tertiary age. In places it is more or less modified by the underlying residual limestone soil. It is a strong, easily handled soil, suitable for the ordinary farm crops, such as corn, wheat, oats, and Kafir corn. Its value for alfalfa has not been tested to any extent, but it is thought that this forage plant might do well on it once a fair catch was secured.

The texture of samples of the soil and subsoil is shown in the table on the succeeding page.

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Mechanical analyses of Sedgwick loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6907	S. ½ sec. 3, T. 28 S., R. 1 W.	Brown silty loam, 0 to 10 inches.	1.28	0.04	2.48	3.06	4.54	10.60	72.54	6.74
6909	W. ½ sec. 25, T. 28 S., R. 1 W.	Reddish-brown loam, 0 to 10 inches.	1.89	.34	5.24	9.46	12.12	11.64	50.84	9.30
6911	NE. ¼ sec. 14, T. 27 S., R. 1 E.	Dark-brown loam, 0 to 10 inches.	3.46	.72	2.94	3.96	10.24	13.00	55.48	13.54
6912	Subsoil of 6911	Heavy loam, 10 to 72 inches.	.50	1.46	3.64	3.76	9.54	12.72	55.96	12.92
6910	Subsoil of 6909	Reddish-brown loam to red sandy clay, 10 to 36 inches.	.77	.90	7.26	11.24	15.40	10.16	40.88	13.54
6908	Subsoil of 6907	Brown silty loam, 10 to 36 inches.	1.70	.06	1.56	1.68	2.78	4.92	72.94	15.20

ARKANSAS LOAM.

The soil of this type is a very dark brown loam, fine grained and mellow, and about 10 inches in depth. In poorly drained spots it is inclined to be a little heavy and sticky, while in areas where it lies in close proximity to the dunes of the Arkansas River it is often modified by wind-blown sand, and partakes somewhat of the nature of a sandy loam. The subsoil, to a depth of from 10 to 24 inches, is composed of a grayish-brown mixture of clay and silt, or very fine sand. The clay in this sometimes predominates so that the texture is quite heavy, and again the fine sand may be more abundant than the clay. In the typical section, from 2 to 3 feet below the surface, the subsoil is made up of interstratified layers of sand, medium to fine in texture, and clay, which is sometimes calcareous, or contains small concretions of lime. Below 3 feet strata of loose, incoherent yellow sand, of a few inches in thickness, are encountered. Along the course of Big Slough, in the northwestern part of the sheet, an area of 2 or 3 square miles exists in which the soil is thinner and the subsoil distinctly more sandy. In the townships of Waco and Salem a small strip of similar character is found extending nearly parallel to and connecting with the Arkansas River.

The soil is found in a typical state of development in the Arkansas River Valley, in the city of Wichita, and vicinity. It is also present along nearly all the streams in the area, though in some instances its characteristics are there somewhat modified. In the Walnut River bottom, in the vicinity of Douglass, the subsoil is usually darker in

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color and slightly finer in texture than along the Arkansas River, and there is an almost complete absence of sand.

The soil is alluvial in origin, having been brought down as a river sediment and deposited in its present position. It occupies a level position from 6 to 15 feet above the streams, and a part of it is subject to almost annual inundation. It is necessary in some localities to resort to artificial means to secure sufficient drainage. In the northeastern part of Waco Township the drainage is particularly poor over an area having its northern limit in the suburbs of Wichita, and containing altogether 3 or 4 square miles. Alkali salts rise to the surface to some extent in this locality in the summer time, and in some small spots have destroyed the vegetation. This area is used wholly for pasturage. The most extensive natural forest growth in the county occurs on the Arkansas loam, and consists of cottonwood, walnut, elm, hackberry, and box elder.

The agricultural interests of the area covered by this type include nearly all of the ordinary farm crops, though wheat is not grown to such an extent as upon the upland. The soil is particularly well adapted to alfalfa because of the comparative ease with which the roots can penetrate the subsoil, and also because the level of standing water is relatively near the surface. Potatoes and other vegetables do well, grapes give excellent yields, and other fruits are grown with profit.

The texture of the soil and subsoil is exhibited by the following analyses:

Mechanical analyses of Arkansas loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6891	S. ¼ sec. 22, T. 27 S., R. 1 E.	Dark brown loam, 0 to 10 inches.	3.19	0.20	1.20	2.52	7.38	19.60	59.34	9.06
6889	S. ¼ sec. 10, T. 29 S., R. 1 E.	Silty loam, 0 to 11 inches.	2.46	.04	1.42	4.06	17.48	20.08	42.44	14.04
6887	W. ¼ sec. 20, T. 29 S., R. 4 W.	Silty loam, 0 to 12 inches.	2.77	.14	.58	.50	1.08	21.64	60.26	15.92
6890	Subsoil of 6889......	Sandy loam, 11 to 36 inches.	.86	.42	1.36	2.70	13.56	23.36	48.66	9.26
6888	Subsoil of 6887......	Black clay loam, 12 to 36 inches.	1.04	.26	.36	.44	.80	3.74	51.42	42.74

MIAMI SAND.

The Miami sand, to a depth of 14 inches, is a loose yellowish-brown sand, medium to coarse in texture. The subsoil is coarser in texture,

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and is in great part made up of reddish grains of feldspar, mixed with quartz, so that the prevailing color is a reddish yellow. The majority of the material of the subsoil is loose and incoherent, though layers of slightly sticky sand are sometimes encountered at depths varying from 2 to 3 feet. At from 4 to 6 feet the subsoil occasionally grades into a fine gravel consisting of well-rounded particles of quartz and feldspar.

This type of soil occupies the western side of the Arkansas River Valley, and occurs as a strip from 1 to 2 miles wide and about 14 miles long. It is separated from the river by the Miami fine sand, which it closely resembles in appearance, having the same general level topography, varied in many places by the presence of low, dunelike hillocks of wind-blown sand from 2 to 5 feet in height. The drainage of the soil is perfect, except for a small part of it lying adjacent to the Big Slough, in Delano Township, in which locality the water is quite close to the surface in the spring and early summer.

Miami sand is derived from material transported by the Arkansas River. Much of this was probably brought down from extensive deposits of Tertiary age in eastern Colorado during a time when the flood plain of the Arkansas was much wider than at present, or at least when the stream flowed at the western side of its valley, and it may also be that a part of the material is derived from the weathering of the near-by Tertiary deposits and has not been carried any great distance.

The soil is adapted to corn, alfalfa, and fruit. Several large apple orchards on this sand are yielding abundantly, and it also finds favor among melon growers. It is also an excellent soil for early truck growing.

The following table gives mechanical analyses of typical samples of this soil:

Mechanical analyses of Miami sand.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6925	S. ½ sec. 26, T. 27 S., R. 1 W.	Brown sand, 0 to 18 inches.	0.82	0.16	5.14	15.90	52.90	20.14	3.26	2.92
6923	N. ½ sec. 11, T. 27 S., R. 1 W.	.....do..............	.78	2.92	14.94	19.96	33.90	17.64	5.50	4.88
6924	Subsoil of 6923....	Sand, 18 to 72 inches.	.19	2.66	12.16	27.08	44.90	9.22	1.96	1.64
6926	Subsoil of 6925....	Yellowish-brown sand, 18 to 36 inches.	.80	.14	2.62	11.66	49.88	24.42	6.40	4.82

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MIAMI FINE SAND.

To an average depth of 12 inches the Miami fine sand consists of a rather loose brown sand, medium to fine in texture, though somewhat coarser phases are sometimes met with. From 12 to 36 inches the subsoil is usually a dark fine sandy loam, interstratified with layers of sand and gray to brown sandy clay. A thin stratum of black fine sandy loam of from 4 to 6 inches in thickness and occurring at from 1 to 3 feet in depth is a prominent characteristic of the subsoil of this type. Below 3 feet strata of loose, incoherent yellow sand are found. In the bands of clay which are interbedded with these strata of sand a few small lime concretions are sometimes seen.

This soil occurs immediately along the banks of the Arkansas River, the larger area lying on the western side. Its contact with the Miami sand is nowhere sharp—in fact, is rarely perceptible from surface indications. Though the average texture of the soil of this type is finer than in the case of the Miami sand, the presence of the heavier material in the subsoil is made the basis for classification. The surface is usually flat, except for the occasional occurrence of low sand dunes. These rarely exceed 4 feet in height, except on the banks of the river, where they are generally much higher. Strictly, these higher dunes at the river bank do not belong with this type of soil, but are rather examples of "dune sand." The area which they cover is too small, however, to be plainly indicated on the map as a separate soil type. No artificial drainage is required, the proximity to the river and the natural porosity of the soil and subsoil serving to carry away surplus surface water.

This soil, like the Arkansas loam, is formed by the deposition of river sediments, the only difference in the derivation of the two types being that the Miami fine sand has been formed by the drifting of the dune sand over the loam.

The soil is especially well adapted to truck raising and is in demand for the cultivation of most varieties of fruit. It seems an ideal melon soil, and apples and peaches bear heavily. Some corn and wheat are grown upon the soil, but its greatest capabilities lie in the direction of market gardening.

The table on the following page contains mechanical analyses of the soil and subsoil of this type.

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Mechanical analyses of Miami fine sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6897	NE. ¼ sec. 16, T. 29 S., R. 1 E.	Brown sand, 0 to 16 inches.	1.11	0.74	3.24	8.24	35.94	22.61	23.84	5.34
6895	SW. ¼ sec. 13, T. 27 S., R. 1 W.	Sand, 0 to 12 inches.	1.57	.18	7.08	14.04	32.38	19.44	19.04	7.84
6898	Subsoil of 6897.....	Grayish-yellow sand, 16 to 36 inches.	1.23	.20	1.18	5.94	31.34	29.38	26.02	5.88
6896	Subsoil of 6895.....	Sandy loam, 12 to 36 inches.	1.04	.16	5.10	13.02	32.80	17.60	18.70	12.40

SEDGWICK BLACK CLAY LOAM.

The soil of the Sedgwick black clay loam to a depth of 12 inches is a fine-grained, black silty loam. The texture at the surface is occasionally somewhat heavier, and the color sometimes approaches a gray. The subsoil is a heavy, tough, bluish-gray to drab clay, extending to 3 feet or more and sometimes containing a small amount of very fine sand or coarse silt. At 3 feet the subsoil is very dry and is penetrated with difficulty. The type occupies flat or basinlike depressions in the upland prairie and is best developed in the southwestern part of the area. It has no adequate drainage. The soil has been formed from the washing down of the finer particles of silt and clay from the surrounding upland soils. It is generally left for pasturage, though thorough drainage converts it into land well adapted to wheat and corn.

The following table gives the result of mechanical analyses of a sample of the soil and subsoil of this type:

Mechanical analyses of Sedgwick black clay loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6919	N. ½ sec. 12, T. 29 S., R. 1 W.	Heavy silty clay loam, 0 to 16 inches.	1.50	0.26	1.04	1.34	8.26	30.80	48.08	9.14
6920	Subsoil of 6919......	Heavy clay or silt, 16 to 36 inches.	.92	Tr.	.60	.64	1.44	15.10	51.60	30.94

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CLARKSVILLE STONY LOAM.

To a depth of about 9 inches the Clarksville stony loam is a yellowish-brown to a brown silty loam, rather loose in texture, and containing from 10 to 20 per cent of limestone and chert fragments. The fragments of limestone range in size from an inch to a foot or more in diameter, and are irregular in shape; the chert is very sharp and angular, and the pieces are from one-fourth inch to 2 inches in diameter. The subsoil usually overlies the bed rock to a thickness of 20 inches or a little more, and is a yellowish-brown clay loam. Contained in it are a good many pieces of limestone, often partially decomposed. Nodular masses of siliceous material, like coarse-textured chert, are not uncommon in the subsoil, ranging from one-half inch to 2 inches in diameter.

This type is found scattered about in small areas in the eastern part of the area in Butler County. It occupies high ridges, and especially hillsides along streams and ravines, particularly the Walnut River and its tributaries, where the underlying stratified rock occurs in loose blocks. It is also found, in a few instances, as small knoblike hills composed of broken pieces of chert and limestone intermixed with the soil. It is derived from the degradation of limestone of the Permian formation. It differs from the Sedgwick black clay loam in being less completely weathered, and in the fact that it contains less organic matter. It is usually too thin and stony to have much agricultural value, but makes good pasture land. The cherty phase of this type would doubtless make a good fruit soil.

The following table gives the results of the mechanical analyses of the soil and subsoil:

Mechanical analyses of Clarksville stony loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6905	E. ½ sec. 13, T. 27 S., R. 4 E.	Loam, 0 to 9 inches.	4.00	1.66	0.80	1.60	2.32	15.94	65.14	12.46
6903	NW. cor. sec. 11, T. 27 S., R. 3 E.	.....do	3.96	.62	.96	1.58	2.00	15.04	63.88	15.92
6906	Subsoil of 6905......	Brown clay loam, 9 to 18 inches.	1.70	.90	2.18	1.34	2.08	10.64	64.08	18.60
6904	Subsoil of 6903......	Clay loam to clay, 9 to 30 inches.	1.12	1.26	1.94	1.32	2.10	5.20	48.58	39.30

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SEDGWICK SANDY LOAM.

The soil of the Sedgwick sandy loam is 10 inches deep and is composed of medium to fine reddish-brown or chocolate-brown sand, carrying considerable organic matter. It is a friable, easily cultivated soil and shows no tendency to form clods. From 10 to 20 inches the subsoil is a reddish-brown, sticky sand, and from 20 inches downward to 36 inches or more this becomes a heavy sandy clay. The sand in this material consists mainly of grains of feldspar and quartz. The type is found mainly in sections 4 and 9 of Delano Township, which lies in the northwestern part of the area. About a square mile of this soil was also mapped a mile or two to the northeast of Clearwater.

The Sedgwick sandy loam occupies a high, gently rolling position on the upland, and in Delano Township forms a low, fairly well-defined escarpment at its junction with the Arkansas River Valley. The drainage of the soil is excellent.

The soil is derived from the weathering of unconsolidated deposits of Tertiary age. It is adapted to corn and wheat and other grains. Fruit does well upon it, and it should prove a good soil for the culture of potatoes and farm vegetables in general.

The following table gives the results of the mechanical analyses of typical samples of soil and subsoil of this type:

Mechanical analyses of Sedgwick sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6921	N. ½ sec. 9, T. 27 S., R. 1 W.	Dark-brown sand, 0 to 10 inches.	1.40	0.34	8.88	18.54	32.12	18.50	13.96	6.98
6922	Subsoil of 6921	Heavy sand, 10 to 36 inches.	1.15	.30	6.84	18.68	27.42	13.58	17.18	21.04

AGRICULTURAL METHODS.

The system of planting and harvesting crops on the Plains differs somewhat from that which obtains in those parts of the country where land is not so easily cultivated, where farms are smaller, and where the acreage allotted to each crop is considerably less. In this area the principal crops, corn and wheat, are usually planted in lots of not less than 40 acres, and the ground being entirely free from stumps and

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stones and so nearly level, it is possible to dispense almost entirely with hand labor. Nearly all the implements used in the cultivation of these two crops are made to be ridden by the driver, though a few walking plows are still in use.

The practice is extensively followed of planting corn with a lister, which method is claimed to be better adapted to the peculiar climatic conditions of the country than the method of planting on a flat surface, as with the check rower. The lister is simply a plow having two moldboards and throwing the earth in both directions. In the bottom of the wide furrow thus made a narrow subsoil shovel travels directly in front of the planter and prepares a mellow trough for the reception of the grain. When the corn is well up and the roots are well formed the ridges are gradually worked into the furrows with a special cultivator or with a sled provided with fenders for the protection of the young plant, so that by the time the stalks are 2 feet high the surface of the field is as level as one in which a check rower has been used. The lister, of course, plants the corn in loose drills rather than in hills. The advantages claimed for this system of planting are that no previous plowing or preparation of the field is necessary, whereby extra labor is saved, and that by reason of the roots being made to grow from 2 to 4 inches deeper in the soil the plant is much better able to withstand drought. For harvesting the use of the corn binder, though not universal, is quite general.

The methods of sowing and harvesting wheat do not differ materially from those followed in other States. With the exception of thrashers, nearly every farmer owns all of the farm machinery which he uses, such as mowers, binders, drills, listers, cultivators, etc.

The soils of Kansas are as yet so productive that but few agriculturists have seen the necessity or advisability of the application of farm manures or commercial fertilizers, and the practice of green manuring and crop rotation is almost unknown. The time will soon come when the present improvident methods must be abandoned and measures taken for restoring to the soil the fertility which the present system of the continuous cultivation of one crop on the same ground year after year inevitably drains from it.

The only irrigation in the area is practiced by a few market gardeners. They have built small reservoirs, which they fill by means of windmills, and from which small vegetable gardens are irrigated. Legal proceedings are at present in progress looking to the curtailment of the amount of water taken from the Arkansas River for irrigation purposes by the farmers in eastern Colorado, and to the consequent increase of the supply that will reach the farmers of Kansas. In this immediate locality it is doubtful if this water will be used for direct irrigation at present; it is wanted more particularly for the subirrigation which is afforded by the Arkansas River in its own flood plain.

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AGRICULTURAL CONDITIONS.

Though Kansas was formerly most widely known for her cattle-grazing interests, her rich and varied agricultural resources were long ago recognized, and for many years she has taken a front rank among the great cereal-producing States. The area selected for the soil survey is one of the richest in the State. The farmers are prosperous and their indebtedness is slight, the majority of them owning and operating their own farms. The farms were originally preempted, and, as a rule, are held in quarter sections, but farms containing 320 acres are not rare, while some of them have an even greater acreage. A few are owned by nonresidents and by retired farmers living in the towns. These are operated by resident tenants, some of whom pay a yearly cash rental ranging from $1.50 per acre upward, while others receive for their labor, tools, seed, etc., from three-fifths to two-thirds of the crops harvested. Hired laborers are all white, most of them American born, and they can be had in fair abundance at a monthly wage of from $18 to $20. The use of highly improved modern machinery makes it possible for the farmer's boy in many cases to do the work of a hired man, so that, in general, hired help is not required by the average farmer except during the three or four busiest months of the season. Through the season of harvesting and thrashing labor of a transient class is usually readily secured at an average wage of about $1.50 a day with board.

Corn and wheat are the crops most extensively grown in the area. In 1899 the acreage of corn in Sedgwick County was 30 per cent, while wheat covered 20 per cent of the entire area of the county. In the same year 42,000 acres of oats were also harvested, while about 7,000 acres each of alfalfa and Kafir corn were cut. Much more alfalfa would be grown if it were not that the soils of the upland do not seem well adapted to it. Kafir corn seems to be excellently adapted to the soil and climatic conditions of the area. This crop is growing in favor, and the acreage is rapidly increasing. Sorghum is also grown to some extent as a forage crop, and by some is preferred to Kafir corn.

It is believed that the profits to be secured from dairying are not sufficiently appreciated. But one or two creameries exist within the area, though there are two or three in adjoining territory. Farmers who have patronized the creameries are as a rule well pleased with their returns, and there is little doubt that a few more creameries would find a field once the farmers became aware of the increased income to be derived from this disposition of their milk as compared with returns from the old method of making butter on the farm. The complaint is sometimes heard of the insufficiency of green forage during the later summer months, due to the inability of the native grasses

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to withstand the hot, dry season. This difficulty can, of course, be overcome by those farmers owning bottom land on the streams, where alfalfa can be readily grown. On the uplands Kafir corn rarely, if ever, fails. It is believed that if greater acreage were given to this crop, and the fodder cut green and preserved in silos, an abundance of feed for dairy stock might be secured at no great expense. The uncertainty of always being able to secure a good harvest of corn or wheat makes it highly desirable that farmers should have some other source of revenue, such as a good herd of dairy cattle or a well-kept and productive orchard.

While apples and peaches yield fairly on the upland soils, there is evident recognition of the superior adaptability of the valley soils for this class of fruit. Upon the Miami sand and Miami fine sand many apple orchards of from 10 to 20 acres and more are to be seen. The trees are thrifty, yield prolifically, and do not seem to be troubled to any great extent by insect pests. Upon the valley loam (the Arkansas loam) grapes give abundant yields, and the common varieties are cultivated to quite an extent. The same soil produces tomatoes of marked superiority. Wichita furnishes a ready market for all kinds of fruits and vegetables, and this demand, combined with that which will be afforded by a canning establishment soon to be erected in Wichita, should encourage the further extension of general gardening and horticulture.

The investigation of the adaptability of the soils—particularly the Arkansas loam—to the profitable growing of the sugar beet is now in progress under the direction of an expert, and it is expected that gratifying results will be shown. If the soil and climate proves favorable a profitable industry can be built up in the Arkansas River valley in the immediate vicinity of the city, where labor is cheap and near at hand.

Transportation facilities throughout the area are unusually good. There are about 110 miles of railroad, operated by four different systems. The seven different lines are so well distributed that no point in the area is more than 9 miles from a station. Wichita is one of the most important shipping points in its relation to Oklahoma, Indian Territory, and northern Texas. The wagon roads of the area are laid out on the rectangular system, following section lines. During rainy weather many of the roads become very heavy, and the sticky soil adheres to the wheels of vehicles to such an extent as to nearly double the draft. The mud is not excessively deep, however, and the nature of the soil is such that when thoroughly dried a firm, hard roadbed results. No toll roads exist.

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SOIL SURVEY OF THE GRAND FORKS AREA, NORTH DAKOTA.

By CHARLES A. JENSEN and N. P. NEILL.

LOCATION AND BOUNDARIES OF THE AREA.

The area surveyed is situated in Grand Forks County, one of the eastern tier of counties of North Dakota, lying a little north of the east and west medial line. The eastern limit of the area is the Red River of the North, which also forms the State boundary line.

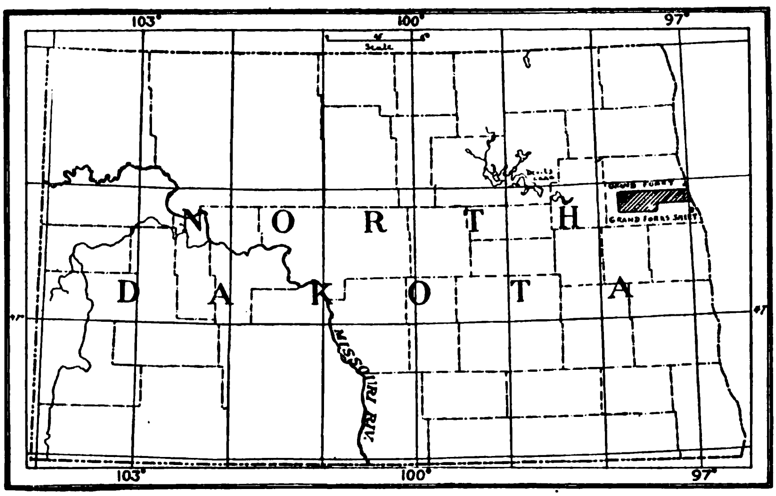

FIG. 19.—Sketch map showing area surveyed in North Dakota.

Grand Forks, in the northeastern part of the area, is situated in about north latitude 47° 55′ and west longitude 97° 05′. The area extends a distance of 34 miles west from that town. For the first 15 miles the area is 6 miles wide, and for the remaining 18 miles it has a width of 12 miles. The area includes T. 151 N., Rs. 50 to 55 W., inclusive, and T. 150 N., Rs. 53 to 55 W., inclusive, and covers an area of 314 square miles or 200,960 acres. Probably most or all of the types of soil in the county occur in the area mapped. (See fig. 19.)

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The Dakotas were originally a part of Michigan, Wisconsin, Iowa, and Minnesota, and during the years between 1834 and 1858 the boun-

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daries were often changed. Civil government of the Dakotas did not begin until 1861, and North and South Dakota were not constituted separate States until 1889.

British and American fur companies were the first to occupy Dakota Territory, and land was not taken up for agricultural purposes until 1851, when a few white settlers obtained a few hundred acres from the Sioux Indians. Agricultural pursuits were, however, often interrupted, even at this late date, by the Indians, who a number of times drove the settlers out of the country.

Grand Forks County was created June 4, 1873, from part of Pembina County. Its boundaries were changed in 1875, in 1881, and again in 1883. The first settlement in the county was Grand Forks, the county seat, which was established late in the seventies. What was but an aggregation of a few houses in 1879 is now a thriving town of 8,000 or 9,000 inhabitants. Agricultural development at that time was limited to a few isolated ranches, as there were no railroad accommodations so far north until 1880–81, when the Great Northern Railway was built through Grand Forks westward. Agricultural development was very rapid along the main line of this road and branches were soon built which gave greatly increased shipping facilities and resulted in a great impetus to farming in various parts of the county and State.

The increase in improved farm lands has, however, been greatest during the last decade, within which time the number of farms and the value of improvements have almost doubled. Much of the western part of the county is not yet improved or developed, being somewhat hilly and less desirable generally than the eastern part.

CLIMATE.

The climate of the Red River Valley may be classed as subhumid. The annual rainfall, which is approximately 20 inches, is usually so distributed as to furnish enough moisture for crop purposes during the growing season. Occasionally, however, a season of drought occurs when crops are practically a failure. The year 1902 was very favorable as regards moisture, but the spring season was late and in a few instances cereals could not be planted in time to mature. The summer months are warm without being uncomfortable, and the fall months cool—conditions required for the proper maturing of the hard variety of wheat grown.

Hailstorms sometimes do considerable damage, and a few of these occurred in various parts of the State in 1902. A small section of the county sustained damage in July by a hailstorm, the force of the wind being sufficient to upset a few houses and telegraph poles.

The wind movement is comparatively high, especially during the

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fall of the year. It is sometimes strong enough during the summer months to badly damage heavy grain, especially if the wind is accompanied by rain, as sometimes happens.

The following table shows the normal monthly and annual temperature and precipitation, taken from Weather Bureau records:

Normal monthly and annual temperature and precipitation.

Month.	Larimore.		University.	
	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	Inches.	° F.	Inches.
January	4.0	0.91	4.0	0.55
February	5.0	.31	6.0	.51
March	17.0	.55	19.0	.62
April	41.0	1.47	41.0	2.88
May	53.0	2.54	54.0	3.14
June	60.0	3.68	63.0	4.32
July	66.0	3.35	67.0	1.96
August	64.0	1.97	....	1.94
September	56.0	.61	56.0	1.12
October	42.0	.79	42.0	.76
November	22.0	.36	22.0	.76
December	13.0	.75	10.0	.62
Year	38.0	17.25	....	19.64

PHYSIOGRAPHY AND GEOLOGY.

The topography of the area is very simple. The level alluvial area extends from Grand Forks west to within about 2 miles of Emerado. The slope of this area is less than 1 foot to the mile. From there westward to the glacial drift there are 8 or 10 beaches or ridges with a northwest and southeast trend, varying in height from a few feet to perhaps 40 or 50 feet, though the latter height is seldom attained in the area surveyed. These ridges are from one-half mile to 2 or 3 miles apart and have very gentle slopes. Often shallow swales extend from one beach to another. Sometimes the beaches form plateaus.

From the Herman beach westward as far as the area surveyed extends there is a rise of perhaps 100 to 200 feet. This is the glacial drift area and consists almost entirely of small hills and hollows or swales scattered about indiscriminately. The individual hills are not extensive in area and vary from 10 feet to 60 or 70 feet in height, with slopes generally not too steep for cultivation.

There are many glacial bowlders scattered about these hills and in the whole of the western part of the area surveyed. These occur in small masses or singly, and some of them are of enormous size. They are, however, not numerous enough to interfere seriously with cultivation.

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There are a number of stream courses, a few deep but most of them shallow, traversing the area in a general easterly direction. With few exceptions these are dry during the greater part of the year.

The area surveyed includes a part of the bed of glacial Lake Agassiz, and extends from Red River (approximately the middle of the valley) to and slightly beyond the upper or western beach of the lake into the glacial drift. The area thus traverses the lacustrine deposits in the middle of the valley, the bench lands and beaches westward, and the upper beach of the lake. The extreme western limit of the area extends several miles into the glacial drift, which corresponds to Fargo gravelly loam. The altitude of Grand Forks is 830 feet above sea level.

The upper beach, several miles west of Larimore, known as the Herman beach, marks the western limit of the lake, while from there to several miles east of Emerado is a series of smaller beaches, representing various temporary stages of the lake during its recession. There are smaller unimportant beaches between Ojata and Grand Forks. These beaches consist of sandy loam, sand and gravel, and reworked till, the surface soil being invariably sandy loam, generally gravelly. Some portions of these beaches, especially those near the western limit of the lake, closely resemble eskers. These beaches were undoubtedly formed by the action of the surf of the lake while its waters remained at one level for longer or shorter periods, in the same manner that beaches are formed at present along the shores of existing bays and lakes. The formation of the beaches was also assisted by the débris continually being unloaded by the floating ice. The coarser material would thus be washed up along these beaches and the finer particles, with occasional pebbles, would settle in the swales between them.

Small kettle holes are quite numerous in the western part of the area and more rarely in the eastern.

The alluvial clay proper, or as classified during the survey, Miami black clay loam, does not appear along the main line of the Great Northern Railway until a point about 2 miles west of Ojata is reached, while west of this the surface soil is sandy loam with a clay or clay loam subsoil. The alluvial silty loam, grading into clay or clay loam at a few feet below the surface, varies considerably in depth and at Grand Forks is probably from 50 to 75 feet deep. This stratified alluvial deposit is underlain by glacial till or drift, which gradually approaches the surface westward, forming the subsoil of Fargo gravelly loam and finally outcropping a few miles west of Larimore as a beach. At Fargo the drift has a thickness of 150 feet. Under this drift is found cretaceous shale, probably the Niobrara and Fort Benton. It has a thickness at Grand Forks of over 300 feet. This is in turn underlain, at a depth of 385 feet at Grand Forks, by granite and gneiss which extends to an unknown depth.

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Over a large part of the area, especially in the west, large bowlders of granite, gneiss, and more rarely limestone are found in local masses, having been dropped by the floating ice. A large number of local beds of crystalline gypsum were found at a depth of from 1 to 6 feet below the surface. Apparently similar beds were also found in the glacial drift.

As gypsum beds are found almost invariably in the slight local rises or ridges in the alluvial soils, and as the texture of the soil in those places is lighter than the surrounding soils, it would appear that these beds are due to gypsum and accompanying salts being dropped there by the floating ice. Against this theory may be urged the fact that bowlders are not found in or around these local rises. Bowlders of fair size are, however, found at a considerable distance east of Ojata, and as gypsum has a lighter specific gravity than granite or limestone, there would at least be a chance of its being carried farther by the smaller floating ice masses. Moreover, the lake must have been comparatively shallow at the time these gypsum beds were laid down, for over some of them there is less than a foot of soil. With the lake at a low stage it would be impossible for large ice masses carrying great bowlders to drift so far eastward.

SOILS.

Five types of soil were recognized in the area surveyed: Fargo gravelly loam, Miami sandy loam, Fargo loam, Miami loam, and Miami black clay loam. Besides these types a number of small areas of muck were mapped.

The texture of the surface soils in the eastern part of the area is as a rule heavier than in the western, the difference being due to the difference in origin. Those in the eastern part of the area are of direct alluvial origin and are loams or clay loams, while those in the western part have been more or less modified by the action of the shore water of the ancient lake and by drift and are consequently lighter in texture.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami sandy loam	68,800	34.3	Fargo loam	12,352	6.1
Fargo gravelly loam	51,136	25.4	Muck	6,592	3.3
Miami black clay loam	44,352	22.1	Total	200,960	....
Miami loam	17,728	8.8			

FARGO GRAVELLY LOAM.

The Fargo gravelly loam, occupying, as typically developed, the extreme western limit of the area, consists of from 1 to 2½ feet of loose black sandy loam with small gravel disseminated through it vary-

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ing in size from very small particles to pebbles about one-half inch in diameter. The surface is also generally gravelly, though over large areas this feature is absent. The surface soil is underlain to a depth of about 3 feet by a black or gray gritty loam, which is in turn underlain by gritty, stiff white or yellow, or mottled gray and yellow loam, containing small gravel and frequently small concretions of iron oxide. This material often grades into clay loam or clay at a depth of 5 or 6 feet. Local beds of crystalline gypsum are often found at a depth of 2 or 3 feet. Over the surface are scattered local masses of glacial bowlders of granite, gneiss, schists, and limestone, but these are not numerous enough to seriously interfere with cultivation.

The topography is undulating, consisting of small irregular hills or knolls of small surface area varying in height from about 10 feet to 40 or 50 feet. Between these are shallow depressions in the shape of swales or kettle holes. The slopes of these hills are not steep and with very few exceptions are easily cultivated. The soil on their summits is lighter in texture than that of the intervening hollows and contains considerable gravel, while the surface soil in the depressions is often very mucky, though not sufficiently pronounced to be classed as muck.

This type is well drained, with the drainage eastward, and many shallow and a few deep creek depressions traverse it, the majority of which, however, are dry during the greater part of the year.

A few local alkali spots were found in this soil, but none of great enough extent to show on a map of the scale used. The clay and clay loam subsoil generally carry some and often considerable alkali, but this does not lie near enough to the surface to interfere with plant growth. The subsoil often carries a very large amount of lime, and when mixed for tests in alkali determinations it gives off a strong mortarlike odor. The lime is probably due to limestone which has been crushed and ground by the ice, as small gravel of this rock of all sizes is scattered through the soil.

The Fargo gravelly loam is largely composed of glacial till or drift, though in the eastern limit of the type the material has been reworked by the wave action of the ancient lake. The soil there gives evidence of having been considerably washed, and hence there is much more gravel and the interstitial soil is lighter than in the area farther west.

This soil is generally adapted to wheat, oats, and barley, and during seasons of favorable rainfall good yields of these crops and of flax can be produced. The soil on the higher elevations does not, however, retain moisture well and is apt to be affected by drought.

Much of this type is still unbroken and unimproved, and such areas bear a splendid growth of prairie grass and would be excellent for grazing range stock.

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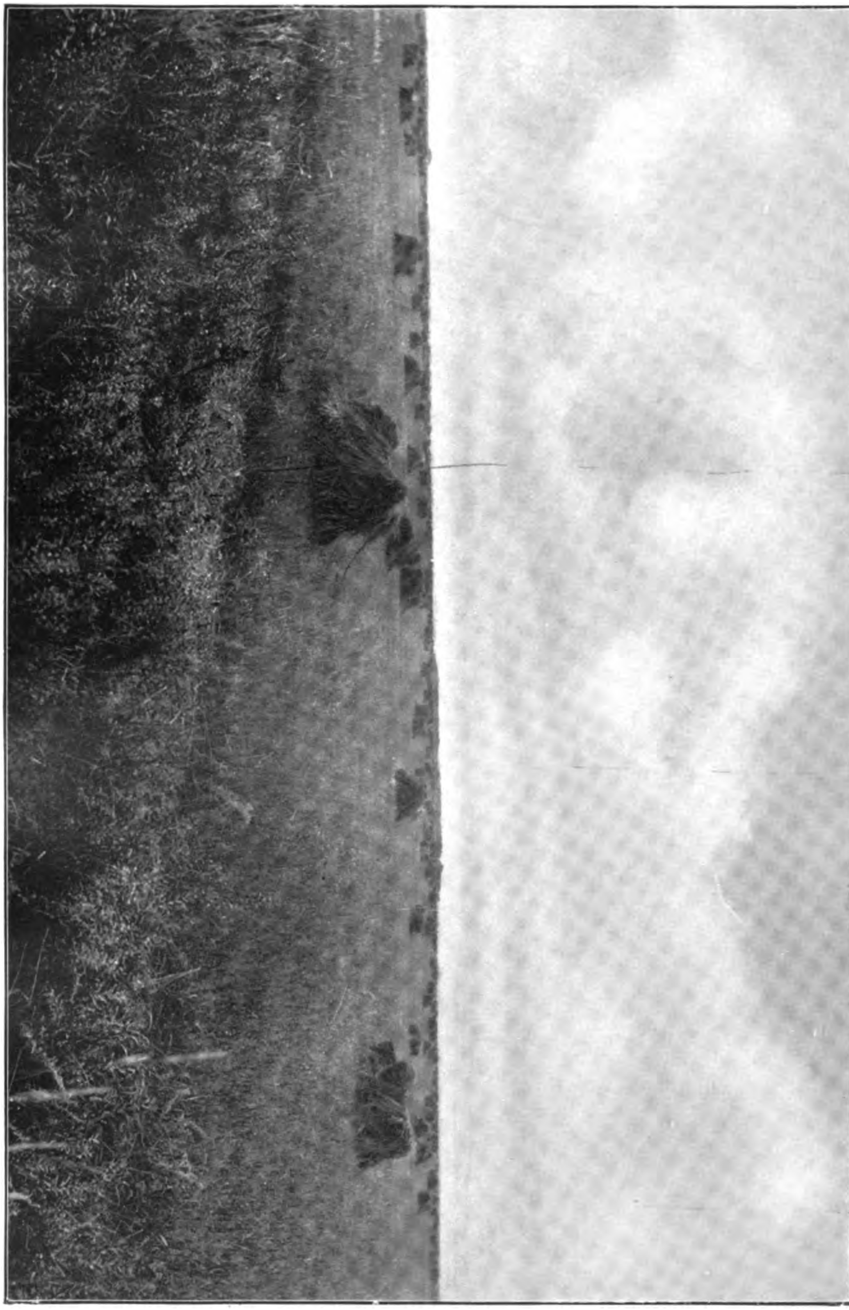

ONE OF THE EXTENSIVE WHEAT FIELDS OF THE RED RIVER VALLEY, GRAND FORKS AREA, NORTH DAKOTA.

The lands are under an extensive system of farming and the yield does not exceed 12 to 15 bushels per acre.

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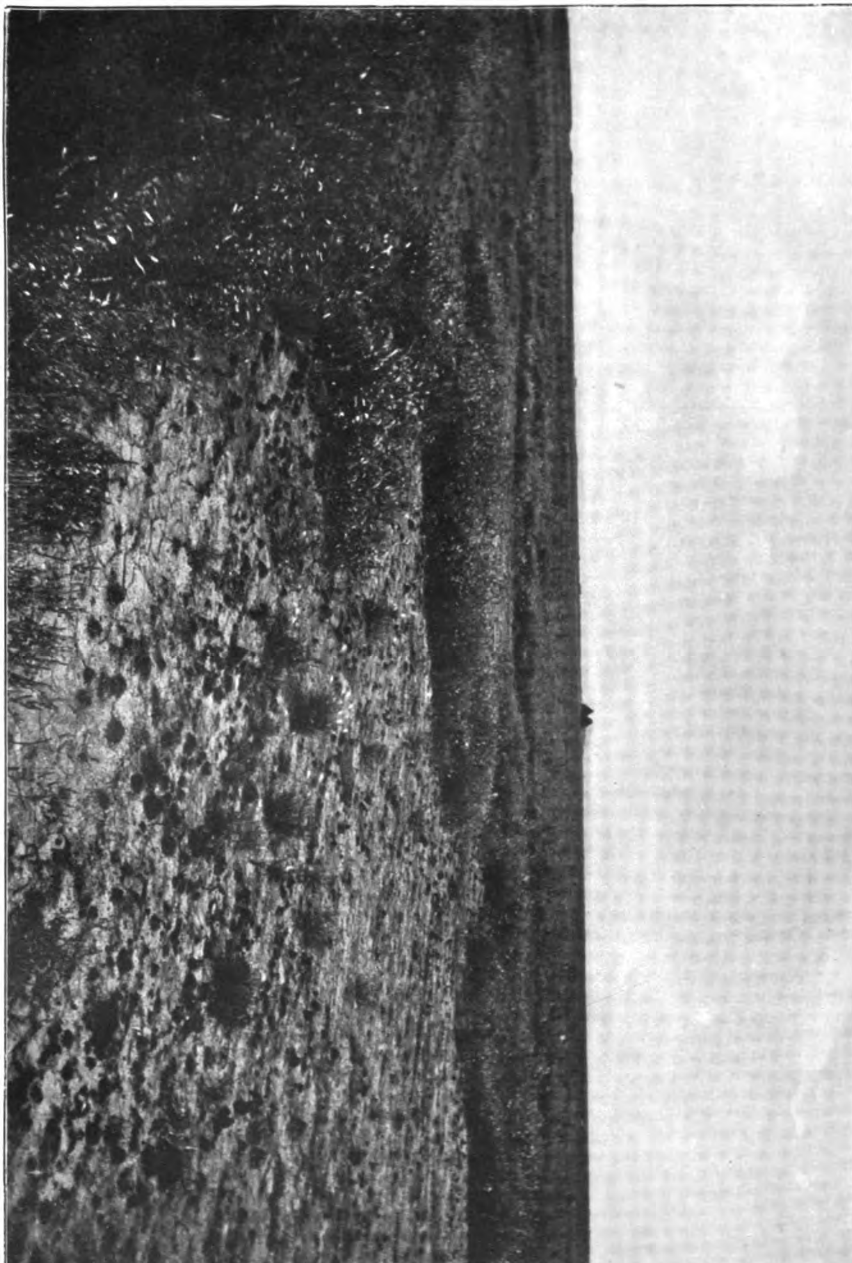

AN ALKALI SPOT, GRAND FORKS AREA, NORTH DAKOTA.

Small areas are frequently encountered with from 1 to 3 per cent of alkali in the surface foot, although usually the alkali is below the surface foot and permits of the growing of wheat and barley.

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A valley phase of the Fargo gravelly loam consists of from 1 to 6 inches of black, sometimes mucky, sandy loam, often containing small gravel, underlain to a depth of 2 feet by a gritty black or gray loam containing small pebbles up to one-half inch or so in diameter. This is in turn underlain to a depth of 6 feet by a gritty, stiff, mottled gray and yellow clay loam or clay, interspersed with small gravel and usually with small concretions of iron oxide. Sometimes the sixth foot, especially in the eastern part of the area, becomes a silty loam of the same material as the subsoil of the Miami black clay loam. Beds of crystalline gypsum are often found in this phase at any depth below the first foot. The surface, especially in the former estuaries of the old glacial lake, is often strewn with glacial bowlders of granite, gneiss, limestone, and schist.

This phase is found in the western and middle parts of the area surveyed. It occupies swales between the beaches and the estuaries of the ancient lake. The latter position is principally found south and southeast of Ojata, where the soil sometimes is intersected by small beaches and ridges.

The areas of this phase of the soil are usually level, though, as before stated, they are often found in low places. Although standing water is on an average only from 4 to 6 feet below the surface, they were not swampy at the time the survey was made. A few of the natural swamps, especially southeast of Ojata, are of this soil type.

The condition of this soil could be considerably improved by artificial underdrainage, using the sloughs which frequently dissect the areas for the main drains or outlets.

There is but little alkali in the first 3 feet of soil in the area west of Larimore, but there is usually considerable in the subsoil. On the other hand the area in and around Ojata is badly impregnated with alkali, both in the surface soil and in the subsoil. This subject will be considered in the chapter on "Alkali in soils."

The area west of Larimore is well adapted to wheat, oats, barley, flax, and corn, but the area in and around Ojata is better adapted to hay and pasturage under present conditions, as there is generally too much alkali in the surface soil for profitable cultivation of the cereals, which make but an indifferent growth. A good crop of wild prairie grasses, including salt grass, was growing on this soil at the time the survey was made. Indeed, over the greater part of the area about Ojata it would be nearly impossible to say whether or not the soil was alkaline without making the chemical test. Grass knee-high was seen on soil containing over 1 per cent of alkali in the first 3 feet, with a uniform distribution.

The table on the following page shows the mechanical composition of the Fargo gravelly loam.

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Mechanical analyses of Fargo gravelly loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7445	SE. corner sec. 9, T. 150 N., R. 55 W.	Sandy loam, 0 to 12 inches.	7.30	1.48	4.64	5.62	13.76	8.30	42.60	22.96
7449	SW. corner sec. 15, T. 151 N., R. 55 W.	Gravelly sandy loam, 0 to 12 inches.	4.87	2.30	6.42	7.84	29.80	11.30	26.22	15.16
7447	E. corner sec. 21, T. 151 N., R. 52 W.	Loam, 0 to 12 inches.	3.92	1.72	4.34	3.76	9.94	15.10	46.86	18.20
7448	Subsoil of 7447	Gravelly clay loam, 24 to 36 inches.	.34	2.28	4.36	4.00	10.62	10.40	47.20	20.78
7451	Subsoil of 7449	Gritty loam, 48 to 60 inches.	1.02	2.94	7.64	6.24	15.86	12.36	32.80	21.16
7450	do	Gritty loam, 24 to 36 inches.	2.80	3.74	6.34	5.92	21.06	9.94	26.62	26.26
7446	Subsoil of 7445	do	1.57	3.26	6.74	5.42	13.68	9.20	35.10	26.26

MIAMI SANDY LOAM.

The Miami sandy loam consists of from 1 to 2 feet of loose black sandy loam underlain to a depth of 3 feet by a gray sandy loam. This is in turn underlain by mottled gray and yellow sandy loam to a depth of 6 feet. Sometimes the sixth foot is yellow sand containing small concretions of iron oxide. Rarely the second foot grades into loam, but in this case the sandy loam is found beneath it. In the southeast quarter of T. 150 N., R. 53 W., the soil has a fine silty sandy loam subsoil that extends from a depth of 3 feet to one of 6 feet.

This soil type is found on the higher-lying areas in the western and middle parts of the area, excepting the glacial-drift area, the typical soil being found in and around Larimore. The beaches, which generally consist of the same material as the surface, contain considerable gravel at a depth of 2 or 3 feet, and this coarser material often outcrops on top of the beaches. Some parts of these beaches, especially near the western limit of the area, closely resemble eskers. The large glacial bowlders commonly found on the other types are usually absent from this one. The soil owes its origin mostly to wave action during the existence of the glacial lake.

The Miami sandy loam is well drained and free from alkali and is generally well adapted to wheat, oats, flax, and barley. Owing, however, to the light and loose texture of the surface soil of some of the areas a plentiful supply of rain is necessary to insure good crops. The beaches are generally too light and loose in texture and often too gravelly to be of any value for agriculture.

This is the only type in which gypsum beds were not found at some depth or other.

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Below are given the mechanical analyses of this soil:

Mechanical analyses of Miami sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.05 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7452	W. center sec. 23, T. 151 N., R. 54 W.	Sandy loam, 0 to 12 inches.	2.79	0.76	3.86	6.88	56.32	6.38	18.94	5.90
7455	Center NW. ¼ sec. 24, T. 151 N., R. 55 W.	.....do	3.59	.10	1.32	3.32	50.76	14.22	18.30	11.10
7453	Subsoil of 7452......	Sandy loam, 24 to 36 inches.	1.22	.64	3.90	7.60	68.94	5.58	5.52	7.02
7454	.....do..............	Sandy loam, 48 to 60 inches.	.72	2.46	9.20	8.24	55.70	6.34	8.60	9.12
7456	Subsoil of 7455......	Heavy sandy loam, 24 to 36 inches.	.86	.24	.88	3.12	43.56	14.32	14.54	22.60

FARGO LOAM.

The Fargo loam consists of about 6 inches of black sandy loam of the same character as the surface soil of the Miami sandy loam, underlain with black loam or light clay loam to a depth of 1½ feet. Beneath this, to a depth of 2 feet 9 inches, is a fine gray, sometimes silty, loam containing no appreciable amount of grit and very much like the corresponding section of the Miami black clay loam. This stratum is in turn underlain to a depth of 6 feet with a fine sandy, usually silty, loam, which is generally mottled, contains small concretions of iron oxide, and is of a gray and yellow color below the fourth foot.

Small beds of gypsum often occur in the second foot, but owing no doubt to the light subsoil there is usually no excess of alkali in the first 3 feet.

The drainage of this soil is usually good, and the type is almost an ideal one for an alkali district, as the light subsoil allows the alkali to be carried away by the underground water, while the surface soil is heavy enough to retain moisture well.

This soil occupies the slight depressions and shallow swales found in the Miami sandy loam area, and owes its origin partly to transportation of the finer particles from the higher lying sandy loam areas, although chiefly to lacustrine deposit during the early period of the recession of the glacial lake.

The soil is well adapted to wheat, oats, flax, barley, and corn. As its ability to retain moisture is greater than that of the lighter soils it withstands drought better, and crops are somewhat surer on this account.

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The following table shows the mechanical analyses of typical samples of this soil:

Mechanical analyses of Fargo loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7457	¼ mile E. of NW. corner sec. 15, T. 150 N., R. 54 W.	Light loam, 0 to 12 inches.	6.28	Tr.	1.60	3.30	39.74	15.74	25.50	13.54
7459	Subsoil of 7457......	Light sandy loam, 48 to 60 inches.	.79	0.20	.94	2.44	50.50	20.24	14.66	10.72
7458	.....do..............	Loam, 24 to 36 inches	1.60	.00	.98	3.14	40.38	15.74	16.78	22.26

MIAMI LOAM.

The Miami loam consists of from 1 to 2 feet of black to brown sandy loam of the same texture as the material composing the surface soil of the Miami sandy loam. This material, without change in texture, grades into a yellow-colored soil beneath which occurs about 1 foot of gray or white gritty loam, often containing small gravel. This is in turn underlain to a depth of 6 feet with a mottled gray and yellow stiff, gritty loam or clay loam, containing a large proportion of small gravel. Usually small concretions of iron oxide are present in the soil below the fourth foot. This subsoil is much like the corresponding section of Fargo gravelly loam, and, like it, carries local beds of gypsum.

There are rarely large enough areas containing excessive amounts of alkali in the first 3 feet of the soil of this type to be indicated on a map of the scale used; that is, there is generally less than the minimum limit of 0.20 per cent. The subsoil, however, usually contains some alkali, and often the amount is considerable.

This soil is found on the slopes of the eastern beaches of the old lake and in intervening areas, being typically developed at Emerado. The sandy loam surface is due to transportation and deposition of material carried over the beaches by the water during the recession of the lake. Some of the areas of the type owe their origin to transportation of sandy loam and sand from the top of the beaches into the swales between them, the sandy loam being really a covering over the Fargo gravelly loam.

The typical areas of this type are well adapted to wheat, oats, barley, millet, and flax, though the lower-lying areas of the type, where the alkaline subsoil is near the surface, do not produce very good crops.

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The following table gives mechanical analyses of this soil:

Mechanical analyses of Miami loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7437	¼ mile S. of NE. corner sec. 2, T. 151 N., R. 52 W.	Sandy loam, 0 to 18 inches.	5.74	1.68	4.74	9.12	12.16	20.64	41.12	10.54
7438	Subsoil of 7437.	Loam or clay loam, 48 to 60 inches.	.47	2.50	3.90	3.96	10.74	9.34	48.14	21.42

MIAMI BLACK CLAY LOAM.

The Miami black clay loam consists of from 1 inch to 4 or 5 inches of muck or mucky loam underlain with black loam, often of a silty texture, to a depth of from 1 to 2 feet. Beneath this is about a foot of fine gray, usually silty, loam that nearly always grades into yellow silty loam at about 3 feet below the surface. This is in turn underlain to a depth of 6 feet with a mottled gray and yellow silty loam, sometimes becoming a silty clay loam in the fifth or sixth foot. Almost invariably small concretions of iron oxide occur in the soil below the third foot. It is this iron that gives the soil its usual yellow color when a depth beyond the influence of dissolved organic matter is reached. The type is very fine in texture and usually does not contain a noticeable amount of sand. Local beds of crystalline gypsum often occur, and are found at any depth in the profile.

For a distance of several miles west of Red River there is in the surface 3 feet of the Miami black clay loam very little alkali, but farther west, as far as the type has been mapped, and especially around Ojata, where the natural drainage is poor, the amount of alkali is considerable. Black alkali was almost invariably found in both the surface soil and subsoil, the quantity varying from a trace to 0.05 per cent in the surface foot, and usually a little less in the subsoil. The black alkali is, of course, not found in areas with free gypsum beds. There was also very often less than 0.20 per cent of soluble salt in the first 3 feet in these places.

Excepting the alkali areas, the Miami black clay loam is generally recognized as being a fine soil for wheat, oats, barley, and flax. The type very well withstands moderate drought, the subsoil being always in fine, moist condition. It would be an excellent soil for celery in seasons of good rainfall.

The area over which this soil occurs is very level, broken only by a few shallow creek depressions which do not at all interfere with cultivation. (See Pl. XXXV.)

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This soil is a lacustrine deposit, and is the only type in the area that has not been modified by other action since the original deposition.

The following table shows the texture of this soil:

Mechanical analyses of Miami black clay loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7442	W. center sec. 36, T. 151 N., R. 51 W.	Loam, 0 to 12 inches.	5.67	0.00	0.20	0.20	1.66	17.10	75.04	4.94
7439	N. center sec. 91, T. 151 N., R. 52 W.	.....do..............	4.02	.36	1.14	1.22	3.56	5.70	64.78	22.88
7443	Subsoil of 7442......	Silty loam, 24 to 36 inches.	.65	.12	.54	.40	.70	9.36	83.82	4.18
7444	.....do..............	Silty loam, 48 to 60 inches.	.46	.00	.36	.30	.56	3.22	79.78	14.82
7440	Subsoil of 7439......	Silty loam, 24 to 36 inches.	.79	.20	.72	.38	.68	4.06	77.42	16.34
7441	.....do..............	Silty loam, 48 to 60 inches.	.53	.16	.60	.50	1.00	2.70	73.12	21.68

MUCK.

The Muck soil is found in many places in different parts of the area, the individual areas varying in size from an acrė or less to about 1 square mile. The type consists of from 1 tq 3 feet of muck, underlain by sandy loam or sand or, rarely, by loam. This is in turn underlain by sandy loam to a depth of 6 feet.

Muck is found in local depressions, such as kettle holes and swales, and generally along the creek courses and in swamps. It is due to gradual accumulation and decomposition of organic matter resulting from the rank grasses which in this area appear to be about the only vegetation growing in these swampy places. In the spring of the year the areas are usually wet and swampy, but during summer they become dry enough to allow the cutting of the grasses for hay.

No alkali exists in this type, its absence being chiefly due to the light subsoil, as, aside from percolation downward, these areas are usually poorly drained.

UNDERGROUND WATER.

A map showing the depth to underground water at the time the survey was made accompanies this report (Pl. XXXVIII).

No general relation seemed to exist between the salt content of the soil and the water table, except where the latter was within 3 feet or so of the surface, when there was generally a noticeable increase of salt in the surface foot of soil.

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The following table shows the results of field analyses of well waters in all parts of the area. With but few exceptions the shallow wells contained less soluble salts than the deeper, and especially the flowing wells. The alkali content of the last ranged from 420 to 1,430 parts of soluble salt per 100,000 parts of water, the salts consisting mostly of chlorides, with sulphates second. The deep and the flowing wells generally contain less of the bicarbonates than the shallow wells.

Chemical analyses of well waters.

No. of sample.	Location.	Depth in feet.	Parts of salt per 100,000.			
			Total salt content.	Bicarbonates.	Chlorides.	Sulphates.[a]
14	¼ mile E. of SW. corner sec. 8, T. 151 N., R. 51 W.	....	250	49	12	189
15	N. center sec. 7, T. 151 N., R. 50 W	(b)	540	42	276	212
52	NE. corner sec. 16, T. 151 N., R. 50 W	(b)	420	38	260	122
52½	Same place as sample 52	5	55	(c)	(c)	(c)
59	SW. corner sec. 2, T. 151 N., R. 50 W	6	130	89	9	32
80	¼ mile N. of SW. corner sec. 34, T. 151 N., R. 50 W.	75	90	(c)	(c)	(c)
81	¼ mile W. of SE. corner sec. 34, T. 151 N., R. 50 W.	7	40	(c)	(c)	(c)
91	½ mile W. of NE. corner sec. 11, T. 150 N., R. 50 W.	....	130	67	5	58
93	W. center sec. 3, T. 150 N., R. 50 W	....	90	(c)	(c)	(c)
106	NE. corner sec. 32, T. 151 N., R. 50 W	7	55	(c)	(c)	(c)
171	S. center sec. 6, T. 150 N., R. 54 W	12	170	63	Tr.	107
178	N. center sec. 11, T. 151 N., R. 55 W	16	28	(c)	(c)	(c)
183	NE. corner sec. 4, T. 151 N., R. 55 W	15	60	52	7	None.
190	¼ mile E. of SW. corner sec. 17, T. 151 N., R. 55 W.	40	250	53	64	133
209	NE. corner sec. 33, T. 151 N., R. 55 W	18	60	58	3	None.
215	NE. corner sec. 29, T. 151 N., R. 55 W	15	360	50	58	252
217	NE. corner sec. 31, T. 151 N., R. 55 W	9	320	50	58	212
227	SW. corner sec. 33, T. 151 N., R. 55 W	10	170	67	21	82
230	¼ mile E. of SW. corner sec. 5, T. 150 N., R. 55 W.	60	180	71	21	88
245	SE. corner sec. 34, T. 151 N., R. 55 W	....	220	60	21	139
316	SE. corner sec. 25, T. 150 N., R. 54 W	8	135	58	3	74
334	SE. corner sec. 26, T. 151 N., R. 53 W	10	135	78	12	45
354	¼ mile N. of SE. corner sec. 1, T. 151 N., R. 54 W.	....	465	87	12	366
374	E. center sec. 12, T. 151 N., R. 54 W	150	560	63	7	490
397	S. center sec. 23, T. 151 N., R. 53 W	9	180	73	23	None.
420	¼ mile S. of NW. corner sec. 4, T. 150 N., R. 53 W.	9	250	55	Tr.	195
450	N. center sec. 11, T. 151 N., R. 52 W	9	110	53	63	None.
456	¼ mile W. of NE. corner sec. 1, T. 151 N., R. 52 W.	(b)	490	42	290	158
473	S. center sec. 16, T. 151 N., R. 52 W	4	340	52	16	272
493	SE. corner sec. 24, T. 151 N., R. 52 W	b 33	560	42	302	216
335	SE. corner sec. 26, T. 151 N., R. 53 W	80	130	80	12	38
519	SE. corner sec. 27, T. 151 N., R. 52 W	b 130	520	73	358	89
529	N. center sec. 35, T. 151 N., R. 52 W	b 44	420	53	202	165
533	¼ mile W. of SE. corner sec. 11, T. 151 N., R. 52 W.	(b)	430	50	813	567
536	NE. corner sec. 13, T. 151 N., R. 52 W	6	70	50	14	None.
564	SW. corner sec. 30, T. 151 N., R. 51 W	b 135	660	45	441	174
578	N. center sec. 1, T. 151 N., R. 51 W	....	720	50	346	324

[a] Sulphates computed by taking the difference between total salt content and bicarbonates and chlorides.

[b] Flowing.

[c] Quantity not determined.

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ALKALI IN SOILS.

The map (Pl. XXXVII), showing the alkali in the soil, departs from the general rule of such maps previously made for areas lying in irrigated and arid regions in one particular, viz, it is based upon the mean amount of salts in the first 3 feet of soil instead of upon the mean in the first 6 feet. The difference in climatic conditions and the fact that shallow-rooted crops form almost exclusively the agriculture of the area made it seem unnecessary to use the more extended profile in this case. It is even thought that a map based on the shallower borings will be of greater value than one where the deeper subsoil was taken into the calculations.

In the Grand Forks area there is generally enough precipitation to prevent the salt in the subsoil from lodging permanently in the surface soil through capillary action, and the roots of the crops commonly grown do not usually, perhaps never, reach deeper than 3 feet. The fact that alkali below this depth, or even at 2 or 3 feet, can have little or no effect on the crop growth was conclusively proved by the condition of the crops seen during the survey. Irrigation is not practiced in the area, and probably never will be extensively practiced, so that the vertical distribution of the salts will not, as in other alkali areas, be affected artificially, and as long as the present method of farming continues in the area there seems no probability that the salts in the subsoil will rise.

A number of determinations were made, however, to depths of 6 and of 8 feet, for the purpose of studying the vertical distribution of the salts in the subsoil. No alkali was found in the Miami sandy loam, even at a depth of 6 feet, and not enough in the first 3 feet of Fargo gravelly loam to map, though considerable quantities were present in the subsoil. The conditions in the case of the Miami loam were similar to those of the Fargo gravelly loam, as typically developed, and in these two types alkali would have been much more general had the salt map been based on the mean of 6-foot borings instead of 3-foot borings, and the conditions would have apparently been much worse than they actually are. Very little alkali was found in the Fargo loam in the first 3 feet, and none was found in the subsoil, as this was much lighter in texture than the soil.

The two types containing injurious amounts of alkali in the first 3 feet, as well as in the deeper soil, are the Miami black clay loam and the valley phase of the Fargo gravelly loam. As shown by the alkali map, the greater part of these two soils carry an average of more than 0.20 per cent of soluble salt at soil saturation in the first 3 feet, and if the map had been constructed to 6 feet the conditions would have appeared worse in practically all parts of these areas.

The worst alkali conditions were found in T. 151 N., Rs. 51 and 52

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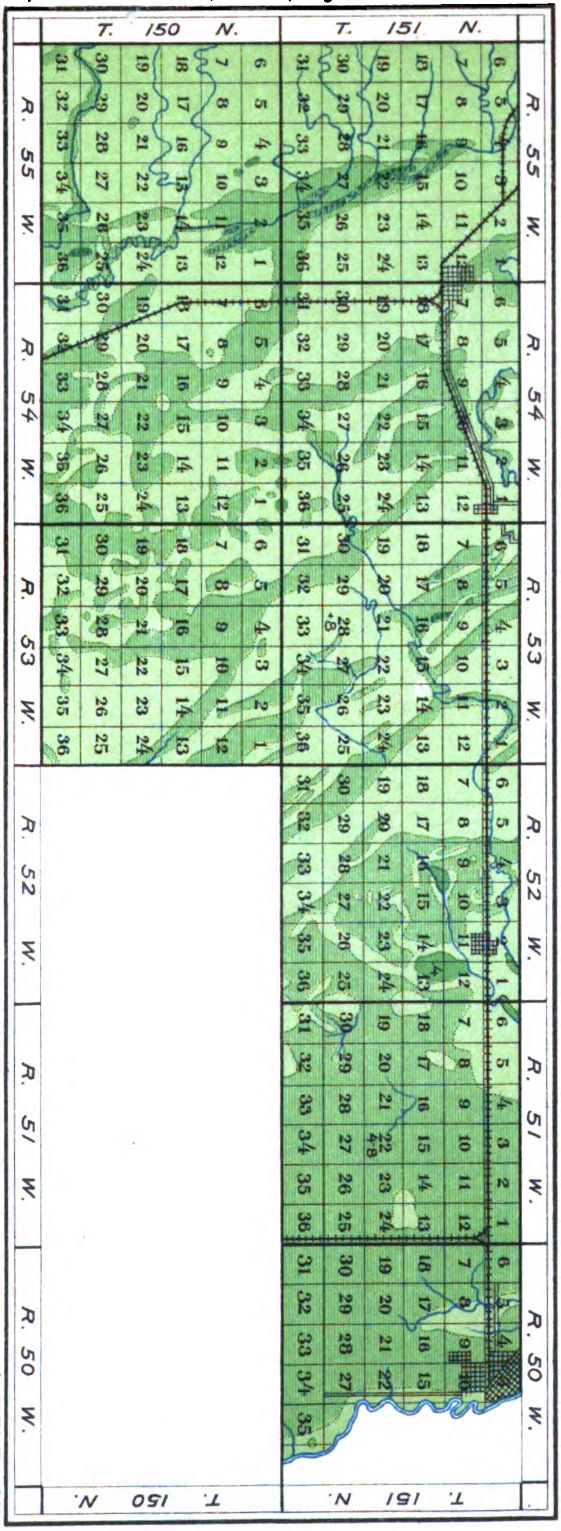

UNDERGROUND WATER MAP, GRAND FORKS SHEET.

Water less than 4 feet below surface.

Water 4 to 8 feet below surface.

+8 Water over 8 feet below surface.

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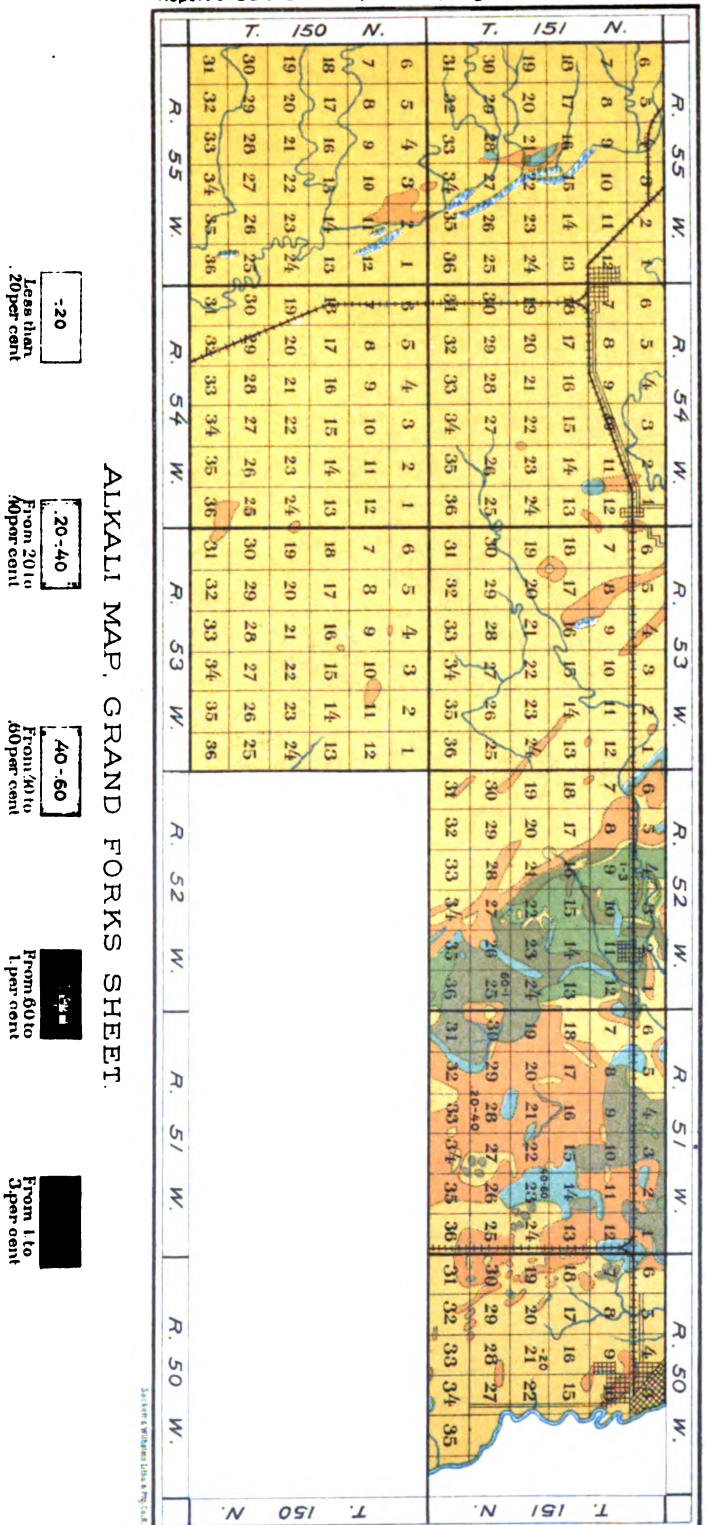

ALKALI MAP, GRAND FORKS SHEET.

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W. This includes most of the strictly lacustrine deposit soils, as the surface soils west of Emerado have been modified by secondary deposits since the lacustrine subsoil was laid down. (See Pl. XXXVI.)

Two ways suggest themselves in which the alkali may have originated. It may have reached the surface by the capillary movement of the salt-carrying, deep-seated waters percolating the underlying drift or Cretaceous shales, assisted by the natural pressure to which these substrata are subjected, or it may have been deposited with the lacustrine material either by being in solution in the lake water, which may have been concentrated, or as being originally in the soil washed into the lake. It does not appear that the lake water ever reached a high state of concentration, and this theory is hardly likely, the origin of the lake considered.

The soil borings can be of little value in determining the origin, except so far as they show the constitution of the alkali. Considerable information on this point is obtained by a study of the table of analyses of well waters given on a preceding page. It is undoubtedly fair to assume that the relation of the salt constituents in the well waters agrees approximately with the solution in the soil from which the water is derived.

The chemical analysis of the standardization solution made in the Bureau laboratory conclusively shows the great preponderance of the acids to be sulphates, these constituting, in fact, more than half of the total amount of salts, with chlorides second, but by no means in large quantities. This solution represents all depths of alkali soils from surface crusts to soil 6 feet below the surface. The various titrations made on soil samples in all parts of the area by the party in the field also brought out the fact that sulphates were generally in excess of any other salt. An inspection of the table of well-water analyses will show that the shallower wells, with but very few exceptions, show sulphates greatly in excess of chlorides.

As no method for the determination of sulphates quantitatively in the field has been devised, these were estimated by difference. The total amount of salt, the chlorides, the carbonates, and the bicarbonates were determined electrically and volumetrically, and it was assumed that the difference between the total amount of salt and the sum of the other constituents mentioned was equal to the sulphates. The results of this method are not, of course, strictly accurate, but are sufficiently so for the purpose of discussion, as no other salts were reported in the complete chemical analyses made in the laboratories.

By referring to the above-mentioned table it will be seen that the chlorides and sulphates occur in altogether different relation in the deeper wells, and especially in the flowing wells, than they do in the shallower wells, i. e., wells with a depth of 20 feet or so. There are

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apparently exceptions, as for instance in Nos. 230 and 335, but as the surface water was not excluded from the deeper seated strata these are of no consequence. The chlorides are in every instance in excess of the sulphates in these deep wells, while in the shallower wells the sulphates are largely in excess. Considered along with this that beds of sulphates, especially gypsum, are quite numerous in the lacustrine deposit and distributed over the entire lacustrine area—Miami black clay loam and valley phase of the Fargo gravelly loam—one can not but conclude that the alkali in the alluvial area in the surface soils was deposited with the soils at the time these were laid down in the lake, and that the alkali water from the deeper and flowing wells belongs to another formation, probably the underlying Cretaceous shales.

With but few exceptions the quantity of salt was found to increase downward. The maximum found was about 3 per cent in the dry soil, and in the worse alkali districts this quantity was found at from 3 to 6 feet. No maximum was found in any one particular foot section, but when once the 3 per cent was reached there was no diminution.

Black alkali was very often, in fact generally, found, even in the presence of small amounts of sulphates, in both soil and subsoil. It was particularly likely to occur in the surface foot, the amounts varying from a trace to 0.07 per cent, though this latter figure was reached in but one place. As much as 0.05 per cent was found in a number of places, but the distribution was not sufficiently extensive or general to warrant the construction of a separate black alkali map.

Good crops of grain, flax, and millet were often found growing on the alkali soils, even where the average amount of salt in the first 3 feet ranged from 1 to 3 per cent. This was due often to the unequal vertical distribution of the alkali, the surface foot carrying but a small part of the total amount. In arid regions such amounts of alkali would with certainty kill any but the most resistant salt grasses, and some areas where most vegetation had succumbed were found in the area surveyed, while in the worst alkali district, in and around Ojata, bare spots were common, these containing a surface deposit of alkali, where even salt grasses and alkali weeds could not exist. However, very fair crops were found to be growing even where the surface foot carried what would usually be considered excessive amounts of salt for agricultural crops.

The table on the following page, while not intended at all to define the exact salt conditions under which crops will or will not grow, shows at least conditions as found in the area surveyed.

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Table showing the relation of the condition of growing crops to the percentage of alkali in the first foot of soil in the Grand Forks area.

Crops.	Condition.			
	Good crop.	Fair crop.	Poor crop.	Killed.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Wheat	0.30	....	....	0.56
	.39	....	....	.76
	.46	....	....	....
Oats	.39	0.58	0.63	....
	.46	....	.84	....
	.51	....	....	....
Barley	.31	.44	.70	....
	.43	.46	....	....
Flax	.32	.37	.52	.50
	.38	.55	.64	.86
Prairie grass and salt grasses	1.16	1.50	....	....
	1.20	2.00	....	....

There are, of course, different crop conditions with the same salt content in the surface foot of soil, as many factors enter into discussion, such as late or early seeding, presence or absence of favorable proportion of moisture in the soil, etc. As these conditions were found in the fall of the year when the crops were matured there can be no doubt about the observations. It should also be kept in mind that in every instance the salt content increased in lower depths, the third foot section carrying more than 1 per cent of alkali in some cases where good crops were growing.

There is but one way to reclaim the alkali flats so that they will grow agricultural crops profitably, viz, by draining them artificially. The subsoil is too heavy in all places to accomplish drainage otherwise. The alkali area in and around Ojata could be drained into the swamps and shallower creek beds or sloughs found there. It would, however, involve quite an outlay of capital, and under present agricultural conditions would probably not be profitable. The drains, however, would not need to be laid as deep as in the more arid regions, as the greater rainfall washes the salts down from the surface and it is not necessary to control accumulation through evaporation. These alkali flats are, however, valuable even in their present condition, as the native grasses growing on the greater part of them make very good hay when properly cured.

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Chemical analyses of alkali soils and crusts.

Constituent.	7460. ¼ mile E. of University; alkali crust.	7461. ¼ mile W. of NE. corner sec. 12, T. 151 N., R. 51 W., alkali crust.	7462. ¼ mile W. of NE. corner sec. 12, T. 151 N., R. 51 W., subsoil 12 to 36 inches.	7463. ¼ mile S. of NW. corner sec. 6, T. 151 N., R. 50 W., subsoil 4 to 6 feet.	7464. ¼ mile E. of SW. corner sec. 22, T. 151 N., R. 50 W., alkali crust.	7465. ¼ mile S. of NW. corner sec. 10, T. 151 N., R. 50 W., alkali crust.	7466. West center sec. 31, T. 150 N., R. 55 W., subsoil 12 to 36 inches.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Ions:							
Calcium (Ca)	6.74	5.83	16.82	13.31	1.76	7.84	24.56
Magnesium (Mg)	14.34	10.74	7.12	5.89	.81	14.24	1.55
Sodium (Na)	1.13	10.69	1.15	1.96	28.44	1.13	.94
Potassium (K)	1.42	.95	2.88	11.44	1.00	.59	1.55
Sulphuric acid (SO_4)	73.94	47.12	59.71	41.93	65.49	73.99	68.94
Chlorine (Cl)	.77	23.59	9.16	20.11	.64	1.56	.64
Bicarbonic acid (HCO_3)	1.66	1.08	3.16	5.36	1.86	1.15	1.82
Conventional combinations:							
Calcium sulphate ($CaSO_4$)	22.28	19.82	57.10	26.45	5.97	24.97	83.46
Magnesium sulphate ($CaSO_4$)	70.99	41.49	24.31	29.22	4.04	70.64	9.99
Sodium sulphate (Na_2SO_4)	2.55	....	....	....	85.91	....	2.35
Potassium chloride (KCl)	1.63	1.81	5.50	21.81	1.35	1.71	1.36
Sodium bicarbonate ($NaHCO_3$)	1.09	1.49	4.29	....	1.99	1.58	.72
Magnesium chloride ($MgCl_2$)	....	9.24	8.80	....	....	....	....
Sodium chloride (NaCl)	....	26.15	....	....	....	1.70	....
Calcium chloride ($CaCl_2$)	....	....	....	15.19	....	....	....
Per cent soluble	10.79	15.50	3.82	2.24	12.96	12.52	5.27

Part of the sodium, varying from 0.24 per cent in sample 7463 to 2.17 per cent in sample 7460, was probably in combination with organic acids, and is therefore not shown in the foregoing table.

AGRICULTURAL METHODS.

The principal products grown are wheat, oats, barley, flax, millet, and hay. Some vegetables are produced for the market, but not much importance is given to this branch of farming. The hay lands are confined chiefly to the low-lying and naturally swampy areas. Wheat is by far the most important crop grown, and the product is very favorably known all over the country for its quality. The wheat is all spring sown and of the hard variety. In 1902 there was a greater area in the county devoted to wheat than to all other crops combined. In the same year flax was second in acreage, it having been grown much more generally that year than ever before. The increase that year was no doubt partly due to a desire to carry on more diversified farming, but also largely to the fact that the season was quite late and much of the land not dry enough in time to allow wheat or oats to mature. Millet was likewise grown more largely in 1902 than in any other year, which was also mainly due to a late spring. These two

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crops need less time to mature than do the cereals, and hence they are sometimes used as emergency crops.

Flax, however, is generally conceded to be an unprofitable crop to grow on the same piece of land for more than two successive years, owing to a peculiar disease known as "flax wilt." The trouble is due to a fungus which appears to be introduced with the seed. When affected the plants turn yellow and partly wilt, and are considerably stunted in growth. If by chance they mature—which a badly affected plant does not—the seed is smaller than the average flaxseed and of a very inferior quality. There seems to be no remedy yet discovered for the disease, and farmers are recommended by the experiment stations to take great care in selecting their seed and to treat it with formaldehyde. The crop is grown almost exclusively for the seed, nothing being as yet done with the fiber excepting a small amount used at Fargo for making hemp. Plans are being seriously considered, however, for putting in machinery at that place (the plant now is small) which would utilize more of the straw and make the industry more general.

There is but little systematic rotation of crops practiced. A number of instances were met with where farmers had planted wheat for eighteen or twenty years without any other crop as alternate, the only break in the scheme being two or three years of summer fallowing. The effect of such constant cropping is quite readily noticed in some parts of the area, though much of the land continues to yield apparently as good crops as ever. When land is considered in need of "rest" it is generally summer fallowed. A decidedly better plan would be to alternate with hoed crops of some kind, but as the farms are generally extensive in area it does not seem to be considered worth while to expend the labor necessary to the production of such crops. More diversified farming could, however, be profitably introduced. Similarly little attention is paid to adaptation of crops to soils, any crop being planted on any kind of land.

Plowing is generally done in the fall, often before the grain is thrashed. This enables the seeding of the land to be done earlier in the spring than when plowing is left until spring, and this is an important matter on account of the shortness of the growing season. It is also a good practice in that it leaves the soil in a better condition for nourishing the next year's crop, as the weathering processes going on during the winter materially increase the available plant food. Especially is this true of the heavier soils.

The amount of seed sown to the acre varies widely, differing with the soil conditions and individual opinion. Any quantity from 1¼ to 3 bushels of wheat per acre is sown, and adherents of both extremes claim the better results. Certain it is, however, that more seed is needed in late sowing than in early sowing, in order that too much

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stooling may be prevented and the crop forced to maturity as early as possible.

Grain harvesting is done altogether with the binder, and the thrashing is done by steam power. Usually the grain is not stacked, but is hauled direct from the shock to the thrasher. Considerable time, trouble, and expense are thus saved; but there is a slight loss attending this method, as wheat, especially, will usually sell a grade better if allowed to pass through the "sweating" process in the stack. It is generally considered, however, that the higher price received is not sufficient to warrant the trouble and expense of stacking.

The yields vary quite widely in different parts of the area, even on the same soil types, the variation depending on a number of factors. It is considered by unprejudiced observers that the average yield per acre is about 12 or 15 bushels of wheat, and this is probably a low enough figure. Forty bushels per acre have been raised with favorable circumstances. Barley yields, on the average, from 25 to 30 bushels, and oats from 35 to 40 bushels per acre. Flax, which is becoming an important crop, averages about 15 bushels per acre. As before mentioned, this crop does better on land that has not been seeded to flax for a number of years. An interesting case was met with in the area, where a piece of land had yielded 25 bushels per acre the first year—a big crop—20 bushels the second, 15 bushels the third, and about 12 to 15 bushels the fourth year. This, however, was on a choice piece of land, and where good care had been given the crops.

Very little fruit has yet been raised or attempted to be raised in the county, the climate being too severe for any but the most hardy sorts.

AGRICULTURAL CONDITIONS.

The agricultural conditions of the State at large have improved greatly and in almost every respect during the last decade. In that time the cultivated area and the number of farms have increased nearly 100 per cent, the acreage per farm has increased from 277 to 343 acres, and the value of farm lands, improvements, buildings, live stock, etc., has almost doubled.

The number of acres in farms in Grand Forks County in 1900 was 861,872. There were 2,368 farms. The average size of farms was 364 acres, and the average value of each, exclusive of buildings and improvements, was $6,327. About 87 per cent of the farm land in the county is improved, and more is constantly being brought under cultivation. Generally speaking, the buildings and improvements are good, especially on the better lands, and the farmers are well supplied with the necessary live stock and implements for the successful operation of their farms.

The population of Grand Forks County is composed almost entirely of the farming class, and little interest is taken in stock raising except

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as an adjunct to the economical operation of the farm. The proportion of the farmers of Grand Forks County owning farms can not be definitely stated, but for the whole State 91.5 per cent of the farms are operated by the owners and 7.2 per cent are operated by share tenants. This would probably be a very fair estimate of the conditions of tenure in the county. Some of the farms classed as operated by the owners, especially the larger farms, are in charge of managers appointed by the owners. The managers have general supervision of affairs and receive a fixed remuneration for their services. Quite often farms are operated by the owners and tenants in conjunction, the tenants receiving a share of the products.

Considerable labor is hired during the busy seasons of the year, and especially at harvest time. This being temporary employment, the laborer is paid considerably more than where the service is permanent, $2.50 to $3 per day for single hands being quite common, the work being shocking grain, assisting in thrashing, plowing, etc. Labor by the month or year is paid much less. According to a report of the county auditor, there were employed on the farms of the county, in 1901, 1,675 male and 347 female employees. According to the same authority, the average wages paid were $24.25 and $13 per month, respectively. There is very little colored help employed in the county.

The transportation facilities of the county are good. The main line of the Great Northern passes through the area from east to west, and a number of branches of this system radiate from Larimore and Grand Forks. The Northern Pacific system also touches the area, passing through Grand Forks.

Along the railroads, at frequent intervals and convenient points, there are small stations, each with from one to half a dozen elevators for storing products temporarily to await shipment. Few farmers have granaries of their own, but deliver their grain to the elevators immediately after it is thrashed, thus usually disposing of it at a lower price than could be obtained later in the year. But as the country is practically new and as many of the farmers have had to pay for their land in yearly payments, many of them are not yet in condition to hold their crops.

A prominent feature of the agriculture of the county is the operation of large farms. These frequently range between 1,000 and 5,000 acres, and in one—the largest in the county, and reported to be the largest grain farm in the world—11,000 acres were sown to crops in 1902. A movement is on foot, however, to have this place divided up into quarter sections and sold to colonists. This would introduce a more diversified farming, dairying, etc., and would be a good thing for the county. Some of the other owners of large farms are seriously considering doing the same thing, and better agricultural conditions will soon obtain if the plan is carried out.

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SOIL SURVEY OF THE BILLINGS AREA, MONTANA.

By CHARLES A. JENSEN and N. P. NEILL.

LOCATION AND BOUNDARIES OF THE AREA.

The Billings area is in the Yellowstone Valley a little east of the central part of the State at approximately 45° 45′ north latitude and 108° 30′ west longitude. It extends from about 1 mile east of Billings to 1 mile west of Park City, a distance of nearly 25 miles. At Billings the area is about 4 miles wide, and it gradually becomes wider westward until at a distance of about 8 miles west of Billings the maximum width of 7 miles is reached. It then suddenly narrows to about 3 miles, which width it approximately maintains to Park City. It is

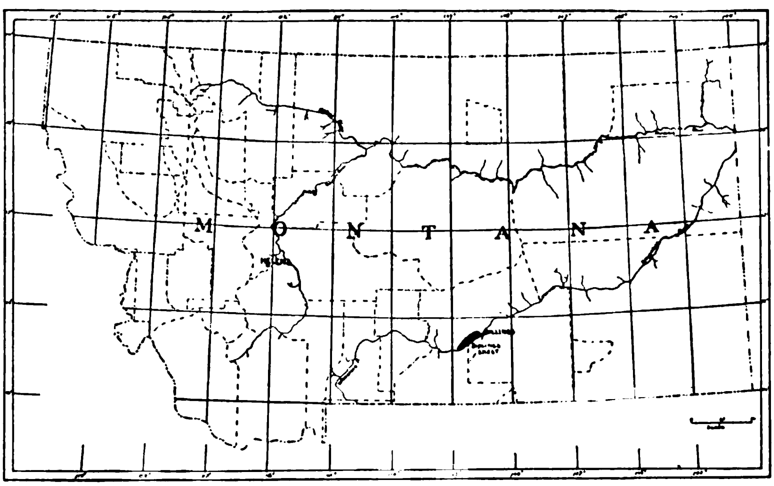

FIG. 20.—Sketch map showing area surveyed in Montana.

bounded on the north by the Highland Ditch and the Minnesota and Montana Improvement Ditch, which follow the sandstone bluff quite closely, and on the south by the Yellowstone River, which flows in a northeasterly direction. The area comprises 68,416 acres, or about 107 square miles.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The earliest known visit of white men to the region now in part the State of Montana was early in the nineteenth century, when a number

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of Jesuit missionaries made their way into the country. For some time after that trapping and fur trading formed the chief occupation of the transient whites. In fact, this was the chief industry until comparatively recent times.

The present boundaries of Montana were not established until 1864, and at that time the State was simply one large cattle range, open to anyone who wished to enter it. Mining was one of the first industries of the State to be developed, and it is to-day one of the most important.

Agriculturally speaking, Montana is very young, and Yellowstone County is one of the latest areas brought under cultivation. The county was organized in 1883, before which time the area formed a part of Gallatin and Custer counties, comprising most of the Crow Indian Reservation. Billings, the county seat, was founded in 1882. The Crow Indians were usually friendly to the white settlers, but the Nez Perces Indians made a raid in 1880, doing considerable damage to stockmen and some of the few other settlers. Aside from this, Yellowstone County has had but little trouble with Indians.

The first known attempts at agriculture were necessarily on a very small scale. In the area surveyed the earliest cultivation of crops was near the confluence of Clark Fork Creek and the Yellowstone River in 1869. Farming, however, was not considered seriously until the extension of the Northern Pacific Railroad into the valley in 1882. The construction of irrigation ditches then began in earnest, and agriculture made rapid growth. The development has been even more rapid since 1890.

The large and much used stock range adjoining the area has been an important factor in promoting agriculture in the valley. Considerable shipments of beef cattle, horses, and sheep are made at the various stations in the valley, being especially heavy at Billings.

CLIMATE.

The south-central part of Montana is semiarid. The 12 inches of rainfall occurring annually in the area surveyed, while not enough for agricultural purposes, very materially aids irrigation, as much of the rainfall comes in May and June. In some seasons the spring rains are sufficient to mature the first crop of alfalfa, and usually one irrigation is enough for the first crop, save in exceptionally dry seasons. During the months of July and August irrigation must generally be practiced. The surrounding ranges receive more rainfall during the season than the valley, which fact is of great importance to the stock interests.

The following table gives the normal temperatures recorded at the Weather Bureau station at Billings. Unfortunately, no record of the rainfall is available.

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Normal monthly and annual temperature.

Month.	Billings.	Month.	Billings.
	° F.		° F.
January	24.4	August	69.3
February	26.5	September	58.6
March	31.1	October	51.5
April	50.5	November	30.8
May	57.9	December	28.9
June	62.9	Year	47.0
July	72.6		

During the summer months the temperature sometimes exceeds 100° F., but the nights are almost invariably cool. During the winter 20° or 25° below zero is sometimes reached, though much lower temperatures, which must be regarded as rather exceptional, are on record. As a rule, considerable snow falls throughout the immediately surrounding country, but during the last two years the snowfall has been quite light.

The wind movement is not generally high; the average for the year would be low, but occasional hailstorms, with strong winds, occur during the spring and early summer, damaging the crops. In one season the grain crops were practically destroyed by hail.

Frosts in spring are not late enough to cause any appreciable damage to the crops at present grown in the area. The average date of the last killing frost in spring, based on the records of six years at Billings, is May 12, and the first in fall September 7.

PHYSIOGRAPHY AND GEOLOGY.

As the part of the Yellowstone Valley surveyed is situated east of the base of the Rocky Mountains, there are no high mountains immediately surrounding the area such as usually hem in the valleys in the intermountain country. The hills surrounding the area are a line of sedimentary ridges rising to a height of from 200 to 500 feet above the valley floor. The sandstone bluffs exposed on the north side, near Billings, consist of medium-grained siliceous sand from 0.5 to 0.1 millimeter in diameter, while the bluffs exposed opposite, on the south side, are of fine-grained, well-laminated shale of a dark color, called Fort Benton shale. The sedimentary deposits are of cretaceous origin and were laid down in salt water—a fact proven by the character of the contained fossils and the comparatively large amount of salt which, in the shale especially, is often found in veins parallel to the bedding.

The Fort Benton shale occurring on the south side of the valley underlies the sandstone on the north side. This is not shown in the

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outcrop at Billings, but is plainly seen in the gullies on the north side of the valley, near Laurel.

Through this sedimentary material the Yellowstone River has cut its way, forming the valley. The sandstone beds in this process were almost, if not entirely, washed away, leaving the shale as the river bed, which can be seen outcropping in a number of places in the abandoned river channels. Since the sedimentary beds were deposited the river has had a number of courses before the present one was selected, and in its meandering it has left considerable waterworn gravel strewn over the surface of the hill slopes of the valley. A very general bed of gravel was also deposited throughout the valley, which has since been covered with soil transported from the hills on the south.

The sandstone bluff on the north side, while appearing as a bluff or a ridge from the valley, really forms the boundary of a plateau covered with a thick layer of soil which, were irrigation possible, would be good farming land. To the south the country is more hilly.

The sandstone is quite porous and readily permits the penetration of water, which follows the planes of bedding, bringing with it in solution the salts which often crystallize out on the perpendicular walls. The shale to the south is finer in texture, shows the sedimentary bedding very distinctly, and can be easily separated along the planes of bedding into very thin sheets. The shale contains considerably more included salts than the sandstone, and beds and veins of gypsum are common. The sandstone is used to some extent for building. Owing to the coarseness of some of the stone and the included salt, care must be exercised in selecting it for such purpose, as the ground water readily disintegrates the coarser material when used for foundations.

Some of the disintegration products of the shale are claimed to be excellent material for the manufacture of tile, but this industry has not yet been developed.

The gravel terrace extending from Billings to Laurel is a former bank of the river.

The physiographic features of the valley are very simple. The northern boundary of the valley is sharply defined by the sandstone bluff. About 1 mile west of Billings a ridge or bench leaves the bluff and takes a southwesterly direction, again joining the bluff at Laurel. At this place the bluff projects quite far northward, making the valley there much narrower than at or west of Billings. This bench is from 10 to 30 feet high and forms a level plateau. The maximum width of this plateau between the ridge and the Highland Ditch is about 4½ miles and its length is about 14 or 15 miles. At about 3 miles west of Laurel another bench gradually forms and again gradually disappears near Park City. This bench forms but a small plateau of about the same height as the larger one just mentioned. South of these plateaus is another level area, which extends to the alluvial soils

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along the river, sloping very gently, almost imperceptibly, in that direction. This area has a maximum width near Billings of about 3½ miles, and from there to Park City varies from 1 mile to 2½ miles in width. The ridge separating these level areas is steep and gravelly.

The alluvial area along the river is from a few feet to 10 or 15 feet below the adjoining areas, and, with the exception of a few shallow channels and draws, it is quite level. The area varies from 1 to 1½ miles in width.

SOILS.

The soils of the area were separated into five different types, as follows: Billings clay, Billings loam, Billings sandy loam, Billings gravelly loam, and Laurel sandy loam.

The subjoined table gives the areas of the soils and the percentage which each is of the total area:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Billings clay	17,088	25.0	Laurel sandy loam	8,832	12.9
Billings loam	14,144	20.7	Swamp	3,008	4.4
Billings sandy loam	13,568	19.8	Total	68,416	....
Billings gravelly loam	11,776	17.2			

BILLINGS CLAY.

As mapped, the Billings clay consists of from 0 to 12 inches of clay loam, underlain by clay 3 to 12 feet in depth, which is in turn underlain by sandy loam, sand, or gravel, though the last is not often found. The clay is dark gray to black, sometimes mottled, tough and sticky, and contains, so far as noticeable to the touch, little or no sand. The clay itself is often 10 to 12 feet deep, and in such cases is practically impervious to water. It packs very firmly in roads and pastures and becomes very hard when it dries. It is locally known as "gumbo." This soil is quite generally distributed over the area, both on the upper plateau and the lower level area between the gravel terrace and the alluvial soils along the river. It is all nearly level, excepting the gentle slopes near some of the foothills. None of it extends near enough to the river to be at all subject to overflow. Generally speaking, the drainage of the areas of this type is poor, and when once the deep-clay areas become saturated with water and subsoil water nears the surface it is a difficult matter to remove it, owing to the close texture of the soil. In the areas having sandy loam or sand underlying the clay at a depth of 2 or 3 feet the drainage is fair and could easily be improved. Such areas generally contain less alkali than the deep-clay areas.

Billings clay owes its origin both to the disintegration of the Fort Benton shale in place and to the transportation of the same disinte-

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grated material. In the lower portion of the valley the first method and in the upper portion the latter method of formation probably prevailed. The small streaks or strata of sand and sandy loam occasionally found are due to transportation of disintegrated sandstone, the latter overlying the shale. As the shale contains considerable quantities of salts, the same is generally true of the derived soils.

The clay is difficult to cultivate to grain crops and if tilled a little too wet forms a very undesirable surface, the clods baking very hard. The surface also becomes very hard when drying after a rain, a very hard crust forming over the entire surface. When not too alkaline this soil is generally well adapted to timothy, blue joint, redtop, June grass, and other grasses. The areas underlain by sandy loam or sand at 3 feet or so are well adapted to alfalfa, though this kind of soil is not as good for alfalfa as the lighter types.

The following table shows the texture of typical samples of this soil:

Mechanical analyses of Billings clay.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6727	[illegible] mile W. of NE. corner sec. 1, T. 1 S., R. 25 E.	Heavy loam, 0 to 12 inches.	0.97	0.00	0.20	0.32	14.22	15.60	37.80	31.54
6721	[illegible] mile N. of S. corner sec. 19, T. 2 S., R. 24 E.	Clay, 0 to 12 inches..	1.07	.14	.56	.98	3.26	8.24	45.08	40.56
6729	Subsoil of 6727......	Clay loam, 48 to 60 inches.	.41	.14	.24	.26	10.32	13.94	39.06	35.42
6723	Subsoil of 6721......	Clay, 48 to 60 inches.	.16	.26	1.40	3.22	5.26	8.00	38.00	43.76
6728	Subsoil of 6727......	Clay, 24 to 36 inches.	.36	.00	.08	.20	9.40	13.10	29.66	46.88
6722	Subsoil of 6721......	....do..............	.36	.10	.46	.60	1.92	5.48	43.64	47.72

BILLINGS LOAM.

The Billings loam consists of 0 to 12 inches of loam, underlain by a light clay loam to a depth of from 2 to 6 feet, which is in turn underlain by sandy loam or sand, and occasionally, though not frequently, by gravel. Part of the area mapped as Billings loam has a surface covering of sandy loam, but practically the only place where this occurs is in the area west of Billings under the gravel terrace.

The Billings loam is gray to black in color, with the same properties, in a less degree, as the Billings clay. It contains generally enough coarse sand to give it a gritty feel. It cultivates quite easily, giving a much more pulverant surface than the clay, and does not

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form so hard a surface when drying after irrigation or rain as the heavier soil.

The Billings loam is found adjoining the Billings clay and Billings sandy loam areas, being quite generally distributed on the upper plateau and around Billings. Like the Billings clay areas it is level.

The underground drainage of this type is generally better than that of the Billings clay, due both to its lighter texture and to the underlying sandy loam or sand and occasional gravel. Much of the area could, however, be considerably improved in this respect, especially that near the center of T. 15 S., R. 25 E.

The Billings loam owes its origin to a mixture of the disintegration products of the Fort Benton shale and the sandstone on the north side of the valley, and thus the texture ranges between sandy loam and clay.

This soil type is adapted to grain and vegetables, especially in the areas with sandy loam surface. It is, however, better adapted to alfalfa and other grasses, such as timothy, blue joint, redtop, etc. Fruit trees are doing fairly well on some areas of this type.

The Billings loam contains some alkali, though not as much as the Billings clay. This will be considered in the chapter on "Alkali in soils."

The following table shows the mechanical composition of this type:

Mechanical analyses of Billings loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6713	¼ mile S. of NW. corner sec. 16, T 1 S., R. 25 E.	Loam, 0 to 12 inches.	1.56	0.04	0.54	0.50	8.38	18.22	40.42	30.98
6714	Subsoil of 6713......	Light loam, 24 to 36 inches.	.30	.00	.16	.48	10.24	18.88	44.30	25.44
6715	.....do...............	Sandy loam, 48 to 72 inches.	.36	.30	.62	.92	11.96	22.76	33.80	29.14

BILLINGS SANDY LOAM.

The Billings sandy loam consists of 0 to 12 inches of loam, underlain by a light-yellow sandy loam to a depth of from 3 to 15 feet, which is in turn underlain by sandstone fragments, gravel, or sand. When approaching loam in texture it becomes a little adhesive. It packs well in roads but tills very easily, forming a very well-pulverized surface. This soil occupies the gentle slopes of the foothills of the sand-

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stone bluff and is seldom found on the lower levels. It is derived from the transported material of the disintegrated sandstone on the north side of the valley. Below the slope of the foothills it gradually becomes heavier, being mixed more or less with the loam or clay derived from the shale underlying the sandstone.

The underdrainage of this type is good, and injurious amounts of alkali are not present except in one small area.

This soil is well adapted to any crop suited to the climate of the valley.

The following table gives the results of mechanical analyses of this soil type:

Mechanical analyses of Billings sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6716	¼ mile NW. corner sec. 2, T. 1 S., R. 25 E.	Sandy loam, 0 to 12 inches.	1.18	0.00	0.50	0.90	30.34	30.61	22.48	14.54
6718	Subsoil of 6716......	Fine sand, 48 to 60 inches.	.29	.00	.24	1.30	43.48	32.44	12.40	9.63
6717	.....do..............	Fine sand, 24 to 36 inches.	.69	.00	.28	.70	38.44	35.52	12.94	11.64

LAUREL SANDY LOAM.

The Laurel sandy loam is an alluvial sandy loam soil, from 2 to 6 feet or more deep, underlain by gravel. Usually the sandy loam grades into sand at lower depths. In color it ranges from a light yellow to nearly black, the soil containing usually much organic matter.

The largest body of this soil occurs east of Park City, stretching eastward in long strips of varying width and separated from the river usually only by the Billings gravelly loam. Another large area lies along the northern border of the area surveyed, branching at a point in sec. 3, T. 3 S., R. 2 E., one fork extending some distance farther north and east along the border and the other occupying a middle course through the valley to within 4 or 5 miles of Billings.

The surface of this soil type is usually level, but it is intersected in many places by sloughs and old river channels, and there are many swampy areas, due to seepage from irrigating ditches. As may be inferred from this, the general drainage of the type is not good, although it could easily be made so, as the subsoil is light and rests upon gravel. In some places the gravel even reaches to the surface. The natural drainage is better in those areas nearer the river.

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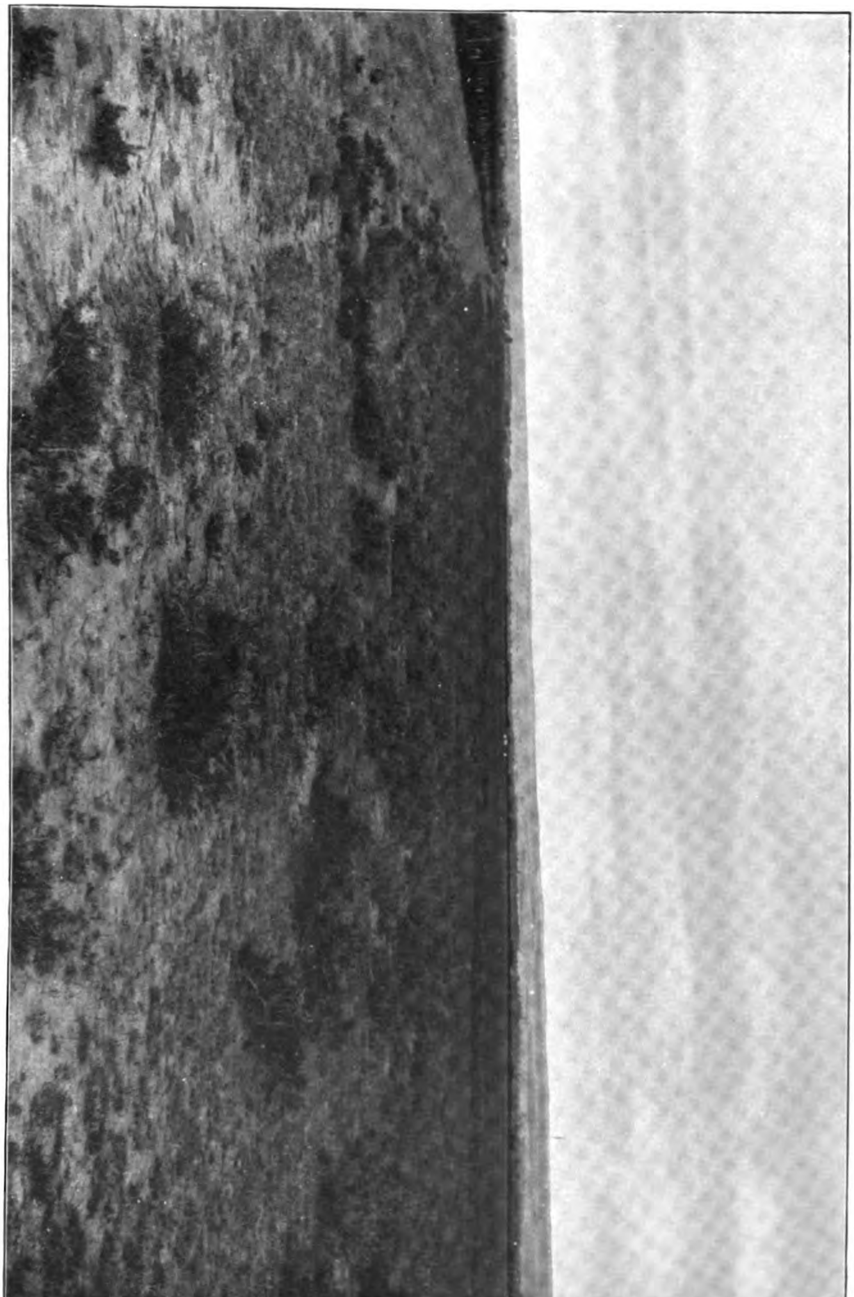

NATIVE VEGETATION OF GREASE WOOD GROWING IN 0.4 TO 0.6 PER CENT OF ALKALI, BILLINGS AREA, MONTANA.

Grease wood always indicates the presence of some alkali, but not necessarily an excessive amount.

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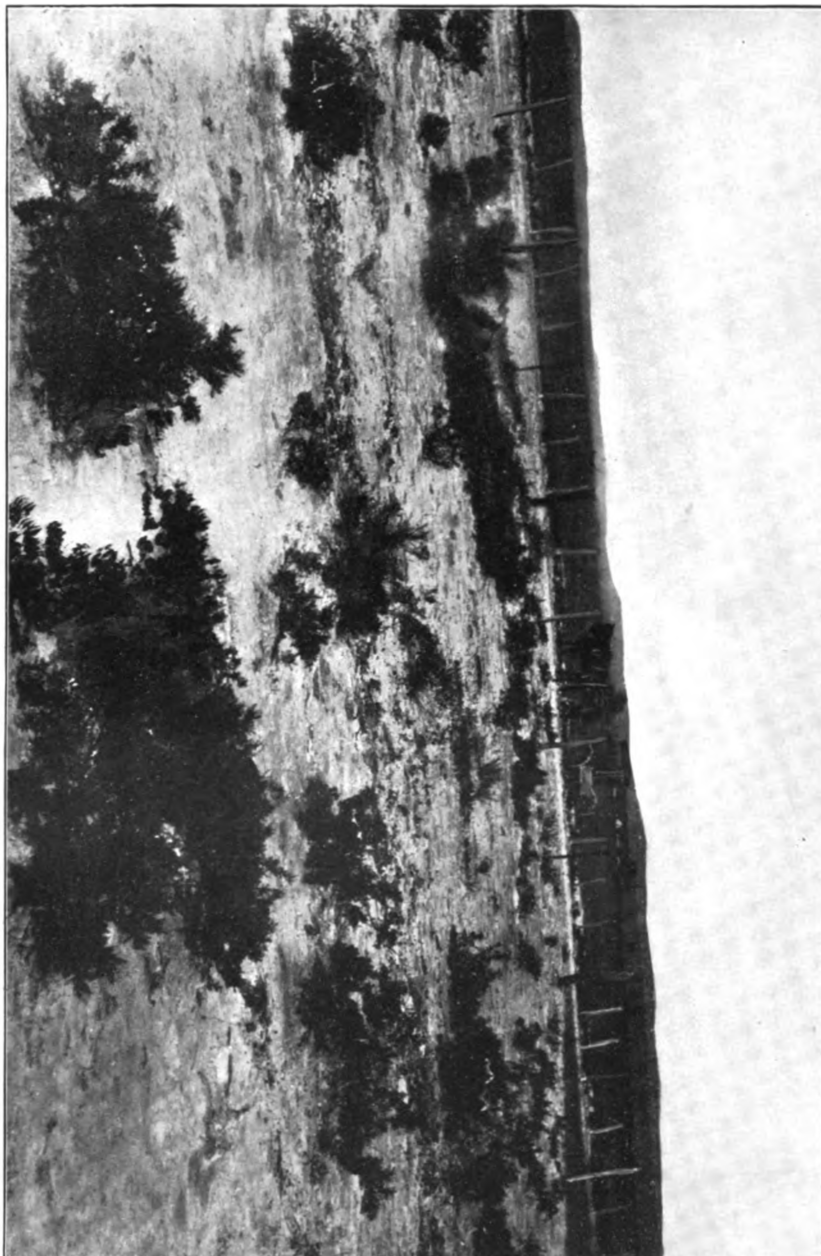

GREASE WOOD GROWING IN AN ALKALI FLAT UNDER THE TERRACE WHERE SEEPAGE HAS PREVAILED, BILLINGS AREA, MONTANA.

The alkali here is too strong for cultivated crops, but reclamation is possible through underdrainage.

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The Laurel sandy loam owes its origin to the Yellowstone River, being composed of deposits of material carried by that stream when it flowed in other channels than the present one.

This soil is the only one in the area found to contain black alkali. The presence of this salt is due largely, if not wholly, to the seepage waters which flow from the higher-lying lands. The part of the area nearer the river, being the better drained, contains less alkali than those parts more remote from the river.

When unaffected by alkali this soil is excellent for grain, vegetables, alfalfa, clover, and fruit.

The following table shows the mechanical composition of the Laurel sandy loam:

Mechanical analyses of Laurel sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6730	SE. corner sec. 10, T. 1 S., R. 26 E.	Sandy loam, 0 to 12 inches.	1.36	Tr.	0.42	1.54	24.48	34.74	29.66	9.58
6733	Near SW. corner sec. 13, T. 2 S., R. 24 E.	Sandy loam, 0 to 12 inches.	1.84	0.30	2.56	4.44	21.44	26.46	31.48	13.28
6732	Subsoil of 6730......	Sandy loam, 48 to 60 inches.	.69	.00	.66	4.50	35.34	29.38	20.90	9.02
6731	Subsoil of 6730......	Sandy loam, 24 to 36 inches.	1.12	.10	.30	2.20	32.74	21.72	30.48	12.42

BILLINGS GRAVELLY LOAM.

The Billings gravelly loam is a sandy loam of the same composition as Billings sandy loam, having a depth of 0 to 18 inches and being underlain by loam or light clay loam of the same kind as found under the other soils of the area and about 3 feet in depth. Beneath this occurs a bed of waterworn gravel, which comes to the surface over most of the area mapped as gravelly loam.

This soil is generally found on or near the terraces, which were former river banks, most of the soil having been removed from these places by transportation, leaving the gravel outcrops. It is free from alkali and well drained.

Near the edge of the terraces it is of little or no agricultural value, being too gravelly, but farther back on the plateau it is well adapted to grain, vegetables, and alfalfa.

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Mechanical analyses of Billings gravelly loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6719	SW. corner sec. 23, T. 2 S., R. 23 E.	Loam, 0 to 14 inches.	1.57	0.52	3.84	6.48	13.66	22.96	28.42	24.04
6720	¼ mile N. of W. center sec. 27, T. 2 S., R. 23 E.	Loam or clay loam, 0 to 14 inches.	.80	.10	1.00	1.78	9.04	16.62	43.48	27.48

SWAMP.

A number of small places throughout the area have been so saturated with seepage water or by excessive irrigation that they have become tule swamps or marshes with free water standing on the surface. These places were mapped as swamp and are of no present agricultural value, being generally too wet even for pasturage. The soil texture of these is generally that of the surrounding soils. They are generally situated immediately below gravel terraces, where seepage water naturally first affects the land.

WATER SUPPLY FOR IRRIGATION.

There is an abundance of irrigating water in the area surveyed; in fact, much more than the present canal system can use, and undoubtedly more than necessary to completely irrigate the whole valley. The supply comes from the Yellowstone River, which has its source in Yellowstone Lake, in Wyoming. This lake, which is constantly fed by springs and the melting of the snows in the mountains surrounding it, acts as a regulator, with the result that the Yellowstone River is much more constant in its flow during the summer months than is usually the case with the intermountain streams. This river after leaving the National Park takes a northerly course into Montana, and thence easterly to its junction with the Missouri River. Besides its source, the Yellowstone has the supply of a number of smaller tributaries before entering the area surveyed.

The following table gives the discharge of the Yellowstone River at Livingston, about 115 miles above Billings, during the irrigating season, as recorded by the Hydrographic Division of the U. S. Geological Survey:

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Mean monthly discharge of Yellowstone River at Livingston, Mont., in second-feet, for six months in 1898, 1900, 1901.

[Drainage area, 3,580 square miles.]

Month.	Year.		
	1898.	1900.	1901.
May	13,402	7,530	1,218
June	15,257	11,415	10,228
July	7,231	4,811	5,534
August	4,099	2,666	3,107
September	2,450	1,878	2,248
October	1,915	1,607	1,926

NOTE.—Records for 1899 incomplete.

The principal canal in the area, as well as the first to be constructed, is what is commonly known as the "Big Ditch," or officially as the Minnesota and Montana Improvement Ditch. The construction of this canal was begun in 1882. In 1890 it was rebuilt, giving it a present capacity of about 300 second-feet at the intake. Its length is 39 miles, extending from a few miles above Park City to Billings. It covers an area of 25,000 acres, of which fully three-fourths is irrigated. "Water right" in this ditch is obtained by purchasing stock, which is negotiable and not permanently attached to the land. The par value of the stock is $10 and the present selling price about $15. One share of stock calls for 1¼ miner's inches (40 miner's inches = 1 second-foot) continuous flow. A board of trustees elected by the stockholders manage the canal. The season of irrigation is approximately from May 1 to October 1. The loss by seepage and evaporation, which has been quite carefully determined, is approximately 25 per cent of the intake.

The Highland Ditch, which was being finished at the time of the survey, is a branch of the Minnesota and Montana Improvement Ditch and will irrigate about 5,000 acres.

Canyon Creek Ditch is smaller and was constructed in 1882–83. It originally had a capacity of about 50 second-feet, but was enlarged in 1891, and it now has a capacity of about 150 second-feet. It covers an area of about 10,000 acres, most of which is irrigated. It is also managed by a board of trustees elected by the stockholders.

The Italian Ditch is another smaller one, which irrigates part of the lower lands south of Park City.

The Suburban Ditch is about 5 miles long, has a capacity of 30 second-feet, and irrigates about 1,600 acres.

These canals or ditches all tap the Yellowstone River, and carry a good quality of irrigation water. A little irrigation is done, however, with seepage water, which, considering the quality, is a dangerous practice. The table following the chapter on seepage waters shows that such water carries considerable salt in solution. Water of this

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character added to soils already alkaline only hastens the day when they must be abandoned. (See Pl. XL.)

As before stated, the irrigating water used in the area is of very good quality. The following table shows the chemical composition of the salt in the canal water:

Chemical analysis of water taken in Minnesota and Montana Improvement Ditch.

Constituent.	Per cent.	Constituent.	Per cent.
Ions:		Conventional combination:	
Calcium (Ca)	6.81	Calcium sulphate ($CaSO_4$)	22.73
Magnesium (Mg)	3.78	Magnesium chloride ($MgCl_2$)	5.30
Sodium (Na)	14.40	Magnesium bicarbonate $Mg(HCO_3)_2$	12.87
Potassium (K)	3.03	Potassium chloride (KCl)	6.81
Sulphuric acid (SO_4)	15.92	Sodium bicarbonate ($NaHCO_3$)	52.29
Chlorine (Cl)	7.57		
Bicarbonic acid (HCO_3)	48.49	Total solids, parts per 100,000	13.2

UNDERGROUND AND SEEPAGE WATERS.

A large number of samples of well, drainage, and spring waters were examined during the field work. All the samples contained considerable amounts of salts in solution. The well waters were particularly impure, the salt content in these varying from 170 to 900 parts in 100,000 parts of water. The table following gives analyses of typical samples gathered in all parts of the area. As the party had no means in the field of determining the sulphates quantitatively, these were tested for qualitatively only. All the samples carried considerable quantities of these latter salts.

As these samples were collected in all parts of the area, it will be seen that the subsoil water is quite generally impregnated with alkali. The wells having the highest salt contents are located in the level clay areas, where the soil texture is heavy to some depth, and in the alkaline areas, where the subsoil water is near the surface. All of the better wells are located on or near the gravel terrace, as would be expected, the underdrainage here being comparatively good. Some areas here and there are not represented in this table, as the people make no attempt to get well water, knowing the general character of it.

Many springs were found along the river bank and below the gravel terrace, and a few of these were examined. Some were much better than the well waters, but as a general rule they were too salty for use.

This condition of the subsoil and drainage waters indicates forcibly both insufficient undergound drainage and the existence of accumulations of salt in the subsoil. Such strongly alkaline solutions could hardly exist in all the wells were the underground drainage good, and the springs would not be so generally salty were there no accumulations of salt in the deep subsoil.

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Chemical analyses of typical samples of well, drainage, and spring water.

No. of sample.	Location.	Depth.	Parts of salt per 100,000. Total salt content.	Bicarbonates.	Chlorides.
		Feet.			
11	S. center sec. 5, T. 1 S., R. 26 E	4	670	176	62
24	S. center SW. ¼ sec. 36, T. 1 N., R. 25 E	10	700	68	16
25	¼ mile W. of SE. corner sec. 36, T. 1 N., R. 25 E	8	144	72	7
44	Center sec. 10, T. 1 S., R. 26 E	10	111	50	7
47	S. center sec. 9, T. 1 S., R. 26 E		681	80	24
54	W. center sec. 17, T. 1 S., R. 26 E	15	500	67	14
55	¼ mile S. of NE. corner sec. 19, T. 1 S., R. 26 E		400	68	16
68	S. center sec. 2, T. 1 S., R. 25 E	12	670	55	23
80	NW. corner sec. 24, T. 1 S., R. 25 E	14	890	161	46
87	½ mile N. of SW. corner sec. 5, T. 1 S., R. 25 E	5	440	83	7
100	NW. corner sec. 3, T. 1 S., R. 25 E	15	690	55	12
116	SW. corner sec. 20, T. 1 S., R. 25 E		400	53	19
120	Near E. center sec. 31, T. 1 S., R. 25 E	8	200	67	9
169	Near SE. corner sec. 24, T. 2 S., R. 23 E	4	172	67	12
174	Near center sec. 8, T. 2 S., R. 24 E	3	880	63	12
17	¼ mile W. of NE. corner sec. 4, T. 1 S., R. 26 E. (drain)		168	42	6
19	E. center sec. 31, T. 1 N., R. 26 E. (drain)		220	63	2
27	S. center sec. 31, T. 1 N., R. 26 E. (spring)		482	23	11
63	¾ mile W. of NE. corner sec. 1, T. 1 S., R. 25 E. (drain)		500	70	83
161	Near center NE. ¼ sec. 7, T. 2 S., R. 24 E. (drain)		170	43	5
173	Near center sec. 8, T. 2 S., R. 24 E. (spring)		450	52	7

Laboratory analyses of sample 47 in preceding table.

Constituent.	Per cent.	Constituent.	Per cent.
Ions:		Conventional combination:	
Calcium (Ca)	7.11	Calcium sulphate ($CaSO_4$)	24.16
Magnesium (Mg)	4.84	Magnesium sulphate ($MgSO_4$)	24.01
Sodium (Na)	15.86	Potassium chloride (KCl)	1.92
Potassium (K)	1.01	Sodium chloride (NaCl)	2.23
Sulphuric acid (SO_4)	62.17	Sodium bicarbonate ($NaHCO_3$)	9.29
Chlorine (Cl)	2.26	Sodium carbonate (Na_2SO_4)	38.39
Bicarbonic acid (HCO_3)	6.75	Total solids, parts per 100,000	681.5

ALKALI IN SOILS.

The alkali map accompanying this report shows the mathematical mean percentage of soluble salts, at soil saturation, of the first 6 feet of soil. This salt content was determined by the electrolytic bridge. Where the vertical distribution of the salt was uniform only the first, third, and fifth foot sections were determined, but in any other case every foot of soil was tested. While the alkali map represents only the first 6 feet, many deeper borings were made to determine the distribution of salt at greater depths.

A comparison of this map with the soil map will show that in general the most alkali is found in the areas classified as Billings clay and

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Billings loam. Alkali is not, however, found in all of the clay areas, as some of these have a light subsoil giving good underground drainage. But wherever the clay extends to a depth of 5 or 6 feet or more, alkali is found. The only exception to this is in the southwestern part of T. 1 S., R. 24 E., where the clay extends to 6 feet or more without injurious amounts of salts.

The vertical distribution of the alkali varies much, this being governed by the texture of the soil and subsoil and by the position of the underground water. In the virgin alkaline clay areas the distribution is quite uniform below the first foot, with the maximum at about 5 feet below the surface. The clay areas in and around Laurel are illustrative of this. With a heavy soil and light subsoil the maximum salt content is in one of the first 3 feet of soil, depending upon the underground water conditions, with a notable decrease at greater depths. The alkali soils in and around Billings are of this kind. In the deep clay areas where irrigation has been moderate and well managed the maximum salt content is from the third to the sixth foot. The alkali areas in and around the western side of T. 1 S., R. 25 E., are of this description. On some of the bench lands and on the alkali soils along the river the maximum amount of alkali is found in the first or second foot, with generally an accumulation on the surface, due to evaporation of subsoil water, which is near enough the surface to be brought up by capillarity.

In 1898 a party from the Bureau of Soils made a study of the alkali soils around Billings, the results of which were published as Bulletin 14 of the Division of Soils. For this report a survey was made of a few square miles lying directly west of Billings and a detailed study was made of sec. 2, T. 1 S., R. 25 E. Lack of drainage was clearly shown to be the cause of the rise of the alkali, and a number of studies were made upon the effect of drains in removing the salt. At that time a few small drains were either in operation or being dug, and large quantities of salt were being carried away. These ditches have been allowed to fill up, and the alkali conditions have not improved since then.

In the unirrigated soils above the canal the amount of alkali in the first 6 feet is usually less than 0.20 per cent. Borings made in 1898 by the party already mentioned and borings made by the present party, as well as the determination made by Dr. Traphagen, showed this to be the general rule. Salts in moderate amounts are, however, often found at 7 or 8 feet below the surface, and generally increase downward. In one of the deeper borings made in sec. 13, T. 1 S., R. 24 E., in a heavy growth of grease wood, no injurious amounts of salts were found until the twelfth foot was reached. From there down to the sixteenth foot the soil was moist and carried considerable amounts of sulphates.

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The source of the alkali found in the upper bench and most of that in the level area south of it is in the shales underlying the sandstone beds on the north side of the valley. The sandstone beds have also contributed a little, but by far the most of it came from the underlying shale. Exposures of this shale in the hills usually showed the walls covered with a deposit of salts, and many smaller beds and veins of salt—mostly calcium sulphate—were found in such places. The origin of the alkali in the Laurel sandy loam is mostly in the seepage water from the bench lands.

The composition of the alkali in the bench soils is quite uniform, consisting principally of sulphates, with small amounts of bicarbonates, chlorides, and some traces of alkaline carbonates. In boring up samples sulphates were often found in both the amorphous and crystalline forms, these having either separated out after the deposition of the soil or been transported as such with the soil. Traces of alkaline carbonates were sometimes found in the bench lands, but quite as often no trace could be detected. The only exception found to this was in sec. 8, T. 1 S., R. 26 E., where the first foot of soil contained about 1.80 per cent of total salt and a little less than 0.10 per cent of black alkali. The other places where black alkali was found were in the Laurel sandy loam, and this is undoubtedly formed from the hydrogen carbonates in solution in the seepage water. These areas carried from 0.05 per cent to 0.10 per cent of black alkali, with the exception of the small salt area in W. center sec. 31, T. 2 S., R. 23 E., which carried about 0.18 per cent of black alkali. These areas always had a surface deposit of white alkali, together with the black.

A noticeable feature in the composition of the alkali of this area is the remarkably small amounts of hydrogen carbonates present. This accounts for the small amounts of normal carbonates, or black alkali. Moreover, there seems to be none in the shale from which the alkali originated. Probably the reason for such small quantities of bicarbonates is due to some extent to the large amounts of sodium sulphate present, which, according to research work done in the Bureau laboratories, drives back the bicarbonates to the normal carbonates. The probable result in the soil would be the formation of lime carbonate.

The analyses of the standardization crusts and solution which follow show the predominating salts to be sulphates, mostly of sodium, this latter constituting from two-thirds to three-fourths of the total. Chlorides are not present in large amounts and estimable carbonates in only two of the crusts, these samples having been collected in the same place in the river bottom soils containing considerable amounts of seepage. It will be noticed that the area with the largest amounts of bicarbonates contains the smallest amount of sulphates, and vice versa.

In this connection it is of interest to compare some of the alkali conditions as they existed in 1898 and as they now are. The following

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table gives data enabling such a comparison of some of the borings made in 1898 with others made in 1902:

Table showing alkali conditions of the soil in 1898 and 1902.

DETERMINATIONS MADE IN 1898.

No. of boring.	Location.	First foot.	Second foot.	Third foot.	Fourth foot.	Fifth foot.	Sixth foot.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
65	¾ mile W. of NE. corner sec. 1, T. 1 S., R. 25 E.	0.57	0.49	0.34	....	(a)	(a)
66	¾ mile W. of NE. corner sec. 1, T. 1 S., R. 25 E.	.64	.38	.31	0.34	(a)	(a)
33	¼ mile W. of SE. corner sec. 2, T. 1 S., R. 25 E.	.19	.24	.44	.46	0.46	0.31
34	S. center sec. 2, T. 1 S., R. 25 E	.70	.52	.41	.32	.32	.27
40	S. center sec. 5, T. 1 S., R. 26 E	.35	.89	.23	.17	.20	....
11	Center NE. ¼ sec. 4, T. 1 S., R. 26 E	.10	.51	.28	.17	....	....
12	⅛ mile NW. of center sec. 4, T. 1 S., R. 26 E...	.32	.41	.41	.47	....	....

a Not determined.

DETERMINATIONS MADE IN 1902.

No. of boring.	Location.	First foot.	Second foot.	Third foot.	Fourth foot.	Fifth foot.	Sixth foot.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
62	¾ mile W. of NE. corner sec. 1, T. 1 S., R. 25 E.	2.20	1.24	0.66	0.58	....	0.66
67	¼ mile W. of SE. corner sec. 2, T. 1 S., R. 25 E.	.54	.41	.51	.60	0.52	.40
69	S. center sec. 2, T. 1 S., R. 25 E	3.00	....	.45	....	.37	....
12	S. center sec. 5, T. 1 S., R. 26 E	.93	.56	.40	.30	....	.36
29	Center NE. ¼ sec. 4, T. 1. S., R. 26 E	.60	....	.25	....	.42	....
30	⅛ mile NW. of center sec. 4, T. 1 S., R. 26 E...	2.50	2.35	1.35	.98	1.20	....

As the method of determination—with the electrolytic bridge—was the same in both instances, these borings can be quite safely compared. It will be seen that the conditions in these places are much worse now than four years ago, as regards salt both on the surface and in the subsoil. This shows the uselessness of trying to wash the salts out of the surface soil by flooding while at the same time the subsoil water is continually bringing the salt to the surface.

From Pl. XLI, which shows graphically the alkali conditions existing in sec. 2, T. 1 S., R. 25 E., in 1898 and in 1902, it will be seen that very considerable changes in the distribution of the salts have taken place during the intervening period, and that the proportion of salt has generally increased. The climatic conditions in June, 1898, were, however, quite different from those in May, 1902. Nearly a whole season's rainfall fell in June, 1898, while the month of May, 1902, received but four or five days' heavy rain altogether. This, in connection with the fact that no irrigation had been done in 1902 before the area in this vicinity was examined, would undoubtedly have some influence on the distribution of the alkali, but could hardly account for the large differences found. This could, however, easily account for much of the difference in depth to standing water, which was nearer the surface in 1898 than in 1902.

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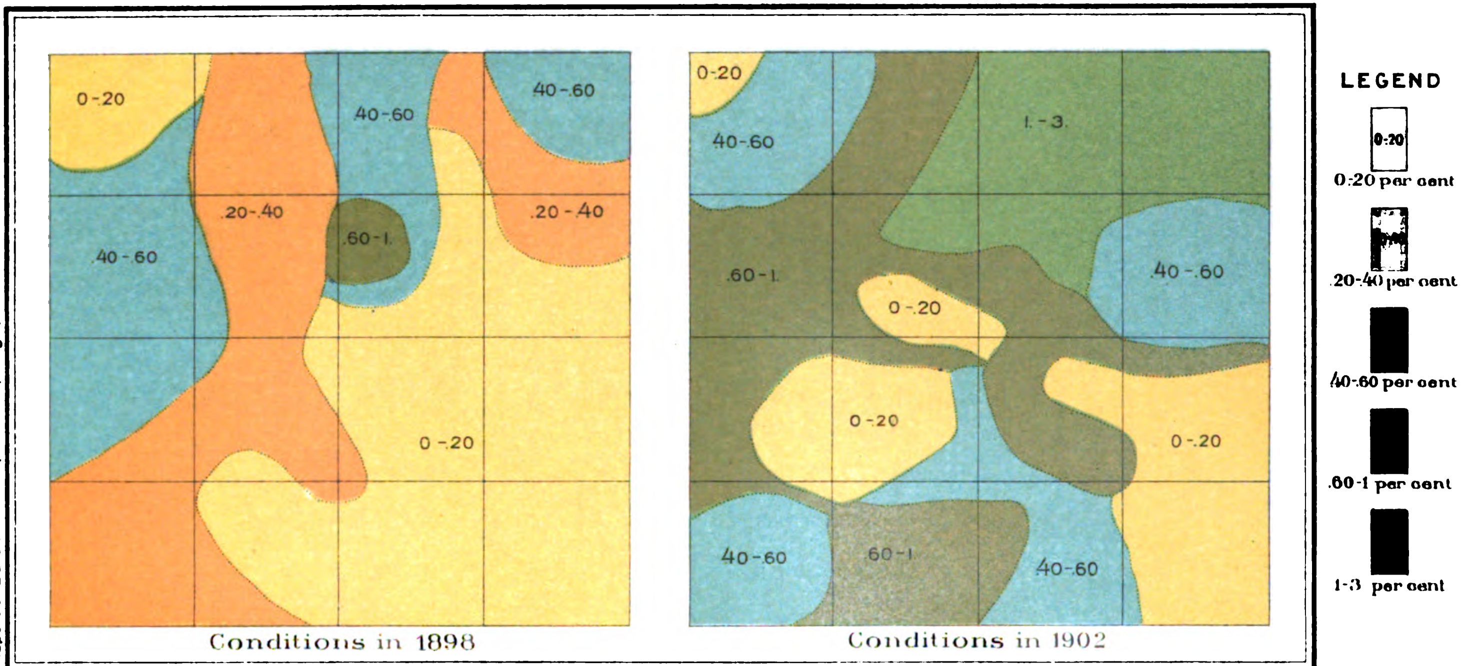

Sackett & Wilhelms Litho & Ptg. Co. N.Y.

ALKALI IN SOILS OF SEC. 2, T 1 S., R. 25 E., AS CONSTRUCTED FROM BORINGS 6 FEET DEEP MADE IN 1898 AND AGAIN IN 1902.

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The determinations made in 1898 by Dr. Traphagen, of the Montana experiment station, would also indicate that alkali conditions are worse now than at that time.

Chemical analyses of crusts used in standardization.

Constituent.	6600. Near NW. corner sec. 2, T. 1 S., R. 26 E., alkali crust 0 to 1 inch.	6601. Center sec. 10, T. 1 S., R. 26 E., soil 0 to 10 inches.	6602. Center sec. 10, T. 1 S., R. 26 E., alkali crust 0 to 1 inch.	6603. S. center sec. 9, T. 1 S., R. 26 E., alkali crust 0 to 1 inch.	6604. Center sec. 8, T. 1 S., R. 26 E., crust 0 to 1 inch.	6605. W. center sec. 34, T. 1 S., R. 26 E., alkali crust 0 to 1 inch.
Ions:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Calcium (Ca)	0.79	2.99	0.16	3.63	4.14	1.85
Magnesium (Mg)	1.79	.85	.24	2.01	2.57	2.95
Sodium (Na)	28.16	20.56	31.73	23.51	22.06	25.03
Potassium (K)	.72	9.63	.88	2.78	2.79	1.08
Sulphuric acid (SO_4)	67.73	45.85	59.93	62.98	61.06	66.49
Chlorine (Cl)	.33	Trace.	1.48	3.24	4.70	1.54
Bicarbonic acid (HCO_3)	.48	16.06	2.83	1.85	2.68	1.06
Carbonic acid (CO_3)	Tr.	4.06	2.75	....	....	....
Conventional combinations:						
Calcium sulphate ($CaSO_4$)	2.71	10.07	.55	12.29	14.00	6.08
Magnesium sulphate ($MgSO_4$)	8.90	4.06	1.22	9.91	12.76	14.58
Sodium sulphate (Na_2SO_4)	85.57	35.12	85.06	66.66	55.68	72.93
Potassium sulphate (K_2SO_4)	1.60	21.41	1.96	6.18	6.15	2.41
Sodium bicarbonate ($NaHCO_3$)	.67	22.06	3.90	2.55	3.69	1.46
Sodium carbonate (Na_2CO_3)	Tr.	7.28	4.87	....	....	....
Sodium chloride (NaCl)	.55	Tr.	2.44	5.41	7.72	2.54
Per cent soluble	44.68	0.934	17.00	2.59	1.79	9.04

Chemical analysis of standardization solution.

Constituent.	Per cent.	Constituent.	Per cent.
Ions:		Conventional combinations:	
Calcium (Ca)	0.89	Calcium sulphate ($CaSO_4$)	3.03
Magnesium (Mg)	1.83	Magnesium sulphate ($MgSO_4$)	9.06
Sodium (Na)	26.24	Potassium sulphate (K_2SO_4)	8.14
Potassium (K)	3.65	Sodium chloride (NaCl)	2.91
Sulphuric acid (SO_4)	63.68	Sodium carbonate (Na_2CO_3)	1.45
Chlorine (Cl)	1.76	Sodium bicarbonate ($NaHCO_3$)	1.56
Bicarbonic acid (HCO_3)	1.13	Sodium sulphate (Na_2SO_4)	73.85
Carbonic acid (CO_3)	.82		

RECLAMATION OF ALKALI SOILS.

As much of the area surveyed, especially the clay areas, was originally heavily charged with alkali, the whole blame for present conditions can not be laid to the seepage resulting from irrigation of the higher-lying lands. That the seepage and drainage waters are doing considerable damage, however, will be apparent by a study of the underground-water map and a consideration of the table of analyses

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of subsoil water given in the chapter on "Underground and seepage waters." It will also be noticed that as a rule the alkaline areas where standing water is within 6 feet or so of the surface have a surface accumulation of salts. Exception to this will be found in the extremely wet areas where the subsoil water reaches the surface, as here the salt is being carried away in solution.

It is very important, then, to keep this subsoil water sufficiently far below the surface to prevent its being brought up by capillarity, as in such case the salts in solution must necessarily accumulate on the surface. The question resolves itself, therefore, into underdrainage. Of course, prevention is better than cure, and much of the area now badly affected by alkali need never have become so if good judgment had been used in the management of irrigation water. However, it is not always, perhaps seldom, that the land damaged has become so by the irrigation of the land itself, but rather by overirrigation of higher-lying lands and by seepage water from canals. It is a pity that there is no redress for the farmer whose land is ruined through no fault of his own. As matters stand, however, there is no permanent remedy except underdrainage when the land becomes affected by salts brought there by irrigation above.

A few people in the area are trying to "reclaim" the alkali soils by running an excess of water on the land, thinking thus to wash off the alkali. It is probably a great temptation to the farmer who has a piece of land resembling a winter landscape to run a continuous stream of water over it in the hope of washing off the salt. As the surface salt is dissolved by the process the land really has the appearance of having been benefited. As a matter of fact, some of the surface salt is washed off; but there is another side to the story. A cursory glance at the table of comparison of borings made in 1898 and 1902 shows that without exception there is more salt in these areas now than there was four years ago, and that surface accumulations are much more common in those areas now than then. The increase is due simply to the bringing up of more salts from below by the subsoil water. With the subsoil water at a safe distance below the surface this could not take place. The filling up of the soil interstices by saturating the soil, thereby raising the underground-water table, is what the farmer accomplishes when he attempts to "reclaim" the land by excessive irrigation, and he not only makes his own land worse, but also that of his neighbor below him.

When, however, good and rapid underdrainage is provided for the excess of water applied, this excess drains away and carries with it the excess of salts dissolved. This method of heavy irrigation on well-drained land has been used for the reclamation of alkaline and saline soils in other countries and has been found successful.

The writer was told by a number of farmers, to whom alkali was

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evidently a new problem, that they intended to put salt on the soil to reclaim it. When told that they already had too much salt on the land, and that it would be worse than foolish to add more, they were not a little surprised. The question was often asked whether something could not be added to "kill the alkali." So far as known there is nothing that could be added to the soils of this area that would materially benefit them. The salts present are generally of the kinds less injurious to crops. There is practically no black alkali in the area, and so it would be useless to add gypsum, as some proposed, even if there was not plenty of gypsum already in the soils.

There is then left no method of reclamation but careful irrigation and thorough underdrainage. The farmers as a rule will not exercise care in irrigation, taking generally as much water as they can get; and underdrainage is expensive and tedious. Some drainage work has been done, but not a single instance was met with in the whole area where drainage had been given a fair trial. A number of 2-foot so-called drains had been dug in some of the worst affected areas, but as the surrounding land was not drained immediately the drains were allowed to fill up and were subsequently abandoned. It follows of necessity that such land as Billings clay must have time to drain, as the soil is very close textured. A drain just west of Billings is the best one in the area, but that also has not been kept clean and in good condition, though the land immediately alongside it has been benefited. Drains to be of real value should be dug deep enough to reach the underlying sand or sandy loam, or if that lies too far below the surface they should be at least 5 feet deep. It is important also to keep the drains constantly clean and in good order.

It must be admitted, however, that draining Billings clay in the areas where the soil is deep is very tedious, laborious, and expensive. It is said that it is cheaper to abandon the farms and buy elsewhere. Of course, so long as this condition exists there is but little incentive to reclaim the alkali lands. But such a condition can not last long in a region that is being developed as rapidly as the area surveyed.

However, many of the alkaline areas can be made to yield fair crops without artificial drainage by adapting the crops to the nature of the soil. By sowing shallow-rooted hay crops and gradually working the surface salt downward the land can finally be improved so that more exacting crops may be grown, though, of course, where the subsoil water is near the surface that must first be gotten rid of by drainage. Importance is sometimes ascribed to the growing crops, alfalfa, for instance, as factors in removing salt from the soil. It is true that much mineral matter is removed in this way, but it may be questioned if alfalfa or any other hay crop will take up much more injurious mineral matter on alkaline than on nonalkaline soils. It seems likely that the benefit is more largely due to the cultivation and careful

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irrigation of the field than directly to the amount of injurious salts taken up by the plant.

The reclamation of the heavier types of soil at Billings will be very slow and probably expensive, very largely on account of the shortness of the irrigation season. The reclamation of the lighter soils is simpler and can be carried on more rapidly and at a lower cost.

The cost of tiling the land will be from $15 to $20 per acre. To this should be added the cost of flooding the land for one to two years before crops can be grown. The total cost of reclamation should not be more than $25 per acre, and when land is thus reclaimed it is insured frcm further damage by either rise of alkali or water.

AGRICULTURAL METHODS.

When the virgin soil is first broken up, which is done at any time of the year except winter, the first crop planted is usually alfalfa, with sometimes enough land reserved for grain, fruit, and vegetables for farm use. Grain is sometimes grown in rotation with vegetables and is the crop usually sown when an alfalfa field is plowed up. As a rule, however, very little attention is paid to rotation of crops, owing to the overshadowing importance of hay production.

The fields are allowed to remain in alfalfa for a considerable length of time, usually being plowed only when the yields appreciably decrease. Alfalfa, if not injured by alkali or unwise management in irrigation, will continue to yield profitably for many years, fields seeded fifteen or eighteen years ago giving as large yields now as ever.

Timothy and blue-joint grass are usually sown on the heavier soils and are seldom plowed up, but are reseeded and harrowed if necessary. Sometimes a dressing of fertilizer is applied at the time of seeding.

The Billings clay is not as a rule devoted to grain crops of any kind, the soil being of such a nature as to make cultivation difficult. An attempt is sometimes made to secure a stand of alfalfa on the more strongly alkaline clay soils when first brought under cultivation, but failure usually results, for these soils often carry a large percentage of salt in the surface foot. Some of the more shallow-rooted crops, such as timothy and blue joint, would do much better until the land is at least partially reclaimed. There is no trouble in getting a crop of blue-joint grass started where alfalfa would make but poor headway. Timothy was found growing in clay soil carrying an average of 0.93 per cent alkali in the first 6 feet, with nearly 0.90 per cent in the first foot, and it was quite common to find good timothy fields with such amounts of salts as these from 18 inches downward. By care in irrigation the alkali could be removed from and kept below the first foot or two, thus securing a good surface soil in which alfalfa would be able to secure a foothold. Alfalfa will itself withstand considerable alkali when once it is well established.

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Sugar beets would also undoubtedly be a good crop to grow on some of the alkali soils, but as there is no factory in the area there is no way of disposing of them except for feed, which would hardly be profitable.

The alkaline soils of the area, even where very badly impregnated, are made use of for pasturage. (See Pl. XXXIX.) A number of grasses, among them foxtail grass, do well, and in their early stage of growth furnish excellent grazing, the young grass being very succulent. Foxtail is usually an intermediary growth between the cultivated crops, before the land becomes badly affected by alkali, and the worst stage, when salt grasses come in. Sweet clover is another crop which will withstand a remarkably large amount of alkali, though not as much as foxtail. While sweet clover becomes rank and woody in the later stages of its growth, it is good feed if grazed while young. A number of salt grasses also serve well for this purpose. Among them the ordinary salt grass is too well known to need special mention.

Flooding is practically the universal method of irrigating in the area, and it is undoubtedly the best method, considering the character of the soils and the crops raised. The heavier soils—Billings clay and some of the loam areas—take water quite slowly, which would make the furrow method a tedious process, besides entailing the loss of much water which would run off at the end of furrows without benefiting the land.

It was found after irrigation of some of the hayfields that the clay soils were wet to a depth of about 18 inches. This is a very good depth for timothy and blue joint, and such irrigation does not fill the subsoil with water and cause injurious rise of alkali. One such field carried on an average about 1.10 per cent of salt for the first 6 feet. The first foot contained but 0.15 per cent, the third 0.30 per cent, and the fifth about 2 per cent. This instance shows the necessity of careful management in irrigation, as the saturation of such soil to a depth sufficient to connect with the subsoil water would soon ruin the field. The perennial rye grass growing here was in splendid condition. A 9-foot boring was made in a similar kind of soil in a virgin state a short distance away. The first foot carried about 1.80 per cent, and from there down the amount of salt increased to the sixth foot. By management similar to that of the field previously mentioned there is no reason why in a short time this virgin land should not be made to yield good crops of the shallow-rooted grasses. Grain seeded on similar soil a few rods away made a very poor growth.

This emphasizes the necessity of suiting the crops to the soils, considering all conditions which affect the crops, such as the texture of the soil and subsoil, amount of alkali, and whether this is uniformly distributed or found accumulated in the surface soil or subsoil. An instance is cited of a farmer who tried for four years to grow vege-

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tables on the kind of soil just mentioned—Billings clay—with large amounts of salt near and at the surface. After that length of time he became bankrupt and moved away. Alfalfa was then tried with indifferent success; rye grass or timothy and blue joint would have done well on this field.

The areas of Billings clay having sandy loam or sand 2 feet or so below the surface would, however, be good for alfalfa, even where the virgin soil does carry considerable salt, as this may soon be moved into the lighter soil underneath by irrigation. As stated in the discussion of alkali in soils, such areas, when cultivated, seldom if ever carried injurious amounts of salt. Again, the planting of deep-rooted crops, such as alfalfa, in fields with light surface soil and clay within 18 or 24 inches containing large amounts of salt is not apt to give gratifying results, as alfalfa will soon show signs of decline with only 18 to 24 inches of good feeding depth. Irrigation on such soils usually increases rather than diminishes the salt content in the subsoil, especially with poor drainage.

The need of the stockmen for a great quantity of winter forage for their cattle and sheep has turned the attention of the farmers of the area to the production of hay almost to the entire exclusion of grain and other general farm crops. Alfalfa of course is the most important hay crop, but timothy and blue joint are also valuable, both for hay and pasturage. Some grain is grown, but the industry holds but a minor place in the local husbandry. Vegetables and fruit do well on some of the soils, so far as attempts at their cultivation have been made. There is as yet no fruit industry, but during the last year or two some orchards of apples, cherries, and plums have been set out. The prize peaches of the State were raised in the Yellowstone Valley in an orchard near Park City. This particular case is, however, an exceptional one, as generally speaking the valley is not a peach-raising district.

Yields of alfalfa vary considerably, depending on the character of soil and the care given it. Three and one-half to 7 or 8 tons per acre are sometimes grown, and the average is not far from 5 tons per acre in 3 cuttings. The yields of 7 or 8 tons are rather exceptional, being usually obtained on favorably situated, light, nonalkaline soils. Prices obtained for this crop vary, of course, with the severity of the winter and the consequent demand for hay by stockmen, but the usual price is from $3.50 to $4 per ton in the stack. The stockmen often make arrangements with the rancher to feed the hay to the stock during the winter, in which case a little more is paid.

Timothy and blue joint are not considered as good for winter feeding as alfalfa, and the yield is perhaps on the average not more than from 1 ton to 1½ tons per acre. The value of these grasses lies not only in the hay product, but also in the excellent pasturage which they

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furnish after the hay crop is harvested. The fields are often used exclusively for pastures, the heavy soils forming a very firm sod and retaining moisture well.

Clover has so far received but little attention, but is now being more generally introduced, though it is not likely ever to replace alfalfa to any great extent.

AGRICULTURAL CONDITIONS.

Generally the farmer or rancher owns his own place and works it himself, hiring labor according to the needs of the work. In some cases farms are leased, the lessor receiving a certain share of the products of the farm. The farms, as a general rule, are well cared for, although haphazard methods are occasionally met with, especially in farming alkali lands, and gross negligence is often seen in the management of irrigation water. This is, however, not always due to lack of intelligence, but to indifference, the majority of the farmers having enough to care for without putting much effort into cultivating land that does not promise good returns. The people are, generally speaking, energetic, wide awake, and prosperous. The average size of the farms is probably about 160 acres, though there are many ranches containing several sections of land.

Transportation facilities are good, the Northern Pacific Railway passing through the entire valley and furnishing four shipping points. However, the principal market for the leading crop (hay) is right at home. The bulk of the crop is consumed by the large herds of sheep and cattle that are brought down to the valley to be fed during the winter. Billings, a very thriving city, is the chief shipping point in the valley, as well as one of the most important in the State. Many cattle and sheep are annually shipped from there over the Northern Pacific and Burlington and Missouri railroads, of which Billings is the western terminus.

Most of the agricultural development of the area has taken place since 1892. The progress has been quite rapid since then and is still continuing, with the prospects that the area will have a very successful future.

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SOIL SURVEY OF THE LEWISTON AREA, IDAHO.

By **LOUIS MESMER.**

LOCATION AND BOUNDARIES OF THE AREA.

The Lewiston area covers about 308 square miles, or 197,248 acres, extending from Lewiston, the county seat of Nez Perces County, northward to Moscow, the county seat of Latah County. The greater

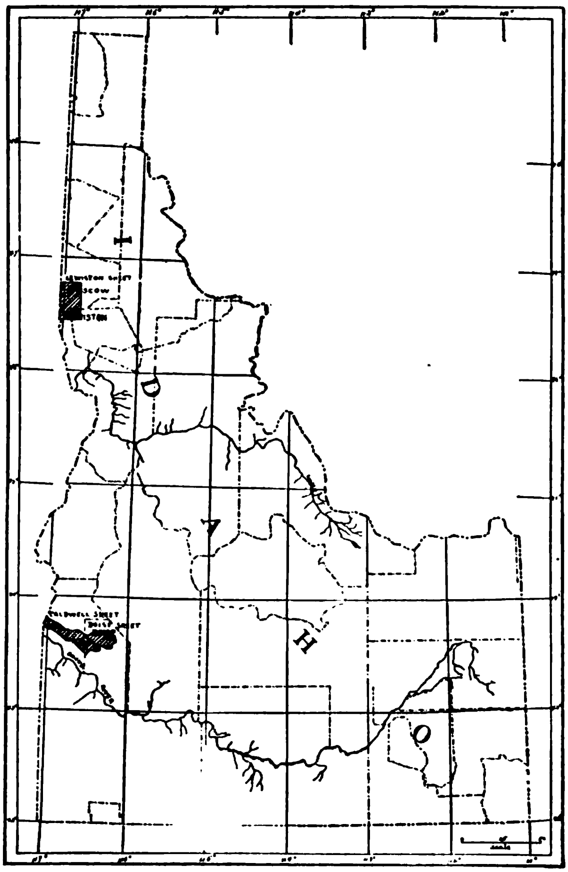

FIG. 21.—Sketch map showing areas surveyed in Idaho.

part of the area surveyed lies within Latah County, a small portion of Washington State being included along the western boundary. Within the limits of the survey are embraced a typical section of the famous Palouse wheat country and, in the vicinity of Lewiston, an important irrigated orchard district. (See fig. 21.)

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HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The news of the discovery, early in the sixties, of rich gold deposits on the Clearwater River caused a great rush of miners and prospectors, many of them gold seekers returning from California, to this part of Idaho. They came in principally by way of the Snake River, stopping at the head of navigation—the junction of the Snake and Clearwater. Here a typical mining town of tents and cabins was rapidly built, which soon became headquarters for mining supplies, attaining at the height of mining prosperity a population of about 5,000.

By the end of the sixties, however, most of the profitable gravel beds had been worked, yielding, it is said, in the neighborhood of $150,000,000 worth of precious metal. There was then little left to hold the miners and the field was shortly deserted, only to be taken up by Chinamen, who continue to work the old placer deposits to this day. With the decline of mining the population of Lewiston (named in honor of the first explorer, leader of the Lewis and Clark expedition) rapidly decreased, a few hunters, trappers, and prospectors soon constituting the community.

About 1874 the first important steps toward agriculture were taken on low-lying, easily irrigated lands along the Clearwater River. The large yields of crops and the prices received for the products were very encouraging and cultivation gradually extended to the uplands. These were covered with great quantities of bunch grass, furnishing abundant pasturage for roving herds of horses and cattle. Here the virgin lands gave much larger returns than anticipated, equal, if not superior, to those given by the Walla Walla country, just over the divide to the west, which was then well under cultivation. Only a short period elapsed before the success which attended the upland experiment was made known to the people of Oregon and Washington and there followed the first important influx of settlers, coming chiefly from those States. By 1880 reports of the phenomenal grain yields of the region had been carried to Kansas, Missouri, Illinois, Wisconsin, and other more eastern States, and settlers then came in so rapidly that by 1883 all the best lands had been taken up and put under cultivation.

This rapid extension of the cultivated area narrowed down the stock ranges and forced the herds into smaller areas, with the result that the grass was cropped too short, most of it was killed, and stock raising on a large scale rapidly declined. Small herds were, however, retained by many, being fed during the winter, and either pastured during the summer on home pastures or driven to the mountains.

Up to 1883 the grain crop was largely consumed in the immediate vicinity and on the Indian reservation, but, with the greatly increased acreage, yielding of wheat 45 bushels, of barley up to 105 bushels, and of flax from 18 to 35 bushels per acre, very large shipments had to be made. These were sent down the Snake River to the Portland

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market. The question of transportation to market was a serious one to those living remote from the river, and profits were dependent in a great measure upon the distance of the producer from the head of navigation.

Attracted by the remarkable fertility of the soils and the wonderful production of grain, a railroad was laid in 1887 to Genesee, resulting in increasing the profits to the farmers in its vicinity and raising the value of land from $10 to $15 and $18 per acre.

With the advent of the railroad also came the introduction of improved stock. Fine horses of the Shire, Belgian, and Clydesdale breeds were brought in, and also beef cattle, principally of the Durham and Hereford breeds. The improvement of live stock was marked and rapid.

Up to 1890 spring wheat had generally been grown, and that on the same ground year after year. The superiority of the hard winter wheat when grown in the area was then discovered, and the increased yield and better quality of grain produced on lands allowed to lie fallow for a season was also observed. These discoveries brought about a change in the agricultural methods, resulting in the substitution of winter for spring wheat and the practice of summer fallowing.

The entire failure of the grain crop in 1893 turned the attention of many grain growers to the handsome profits realized by orchardists along the Clearwater River, and many prune, apple, pear, plum, and other fruit trees were set out on the uplands. These orchards grew well, but the season was found to be too short to permit the perfect development of fruit, excepting apples, cherries, and some varieties of pears. The new industry was therefore not attended with the profit expected, and production is limited mainly to home supply.

The opening of the Nez Perces Indian Reservation to settlement in 1895 forms another important event in the development of this country. The Indian lands were rapidly taken up, furnishing homes for about 3,000 families. This greatly increased the grain output and brought the section into greater prominence. The large area farmed on the reservation resulted in an extension of the Northern Pacific Railroad, which in 1898 was laid through Moscow to Lewiston.

The crop production of the Lewiston area has fluctuated considerably with the seasons, and the prosperity of the farmers with the varying price of grain, which during the financial depression of 1893–94 was extremely low. The seasons since 1897 have all been good, and during this period the country has made great and steady advancement along all the various lines of industry.

CLIMATE.

The climate of the Lewiston area is characterized by low humidity, moderate wind movement, and a long, dry summer, the greater portion of the rain falling between the 1st of November and the last of

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May. The summer temperature for the lowlands lying along the Clearwater River is quite high, but that of the greater part of the area, situated in the same plateau with Moscow and Genesee, is exceptionally pleasant, with mild days and cool nights.

The following table gives the normal monthly and annual temperature and precipitation at Lewiston and Moscow, the figures being taken from Weather Bureau records for the past eight and nine years, respectively:

Normal monthly and annual temperature and precipitation.

Month.	Lewiston.[a]		Moscow.[b]	
	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	Inches.	° F.	Inches.
January	35.5	1.30	29.0	2.98
February	38.4	1.18	31.2	2.71
March	43.6	.78	36.8	1.94
April	53.1	1.02	45.8	1.60
May	60.4	2.03	52.7	2.37
June	65.8	1.09	58.1	1.36
July	74.4	.44	66.8	.49
August	74.7	.57	65.0	.86
September	62.3	1.00	57.2	1.35
October	53.8	1.42	47.9	1.79
November	42.5	1.84	36.7	3.21
December	37.4	1.27	32.2	2.56
Year	53.5	13.94	46.6	23.22

[a] Elevation 757 feet. [b] Elevation 2,569 feet.

An inspection of the foregoing table will reveal decided differences between the temperatures and precipitations of Lewiston and Moscow. This is due to the difference in elevation, Moscow being about 2,000 feet higher than Lewiston. As the greater part of the area lies in the same plateau with Moscow and has about the same elevation, the data given for this station may be taken as fairly typical of the section, while that for Lewiston represents the conditions in the territory south of the Clearwater River and in a small section along the north bank.

The general conditions of the two sections, lowland and upland, may be summed up in a few words. The latter has mild summers, moderately cold winters, snow seldom remaining for any length of time, and abundant rainfall, the complete failure of ordinary crops for lack of moisture being unknown. The former has warm summers, moderate winters, zero weather being the exception, and a normally light rainfall, the ordinary field crops suffering occasionally for lack of moisture.

PHYSIOGRAPHY AND GEOLOGY.

In describing the present relief of the country under consideration it may not be amiss to give a brief description of the topography of the original land surface, the subsequent intrusion of the lava, and

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the different agencies which have since been brought to bear and to which the present topography owes its existence.

The original topography was widely diversified, consisting of a much denuded land surface, where schist, diorites, and other igneous rocks that were formed many feet below the earth's crust and brought to the surface by the active agency of erosion predominated. Fissures in the earth's crust gave forth immense volumes of fluid magma which spread over the then existing surface, gradually filling up the depressions and modifying the relief. Over an area of several hundred square miles in eastern Washington the lava has been eroded away, laying bare the rock on which it originally rested. Here hundreds of dikes of dense basalt, ranging in size up to 150 feet in thickness, may be seen. Many other dikes of this character undoubtedly exist over the area, and, as erosion and denudation goes on, will be brought to the surface. An idea of the enormous volume of lava poured out in forming the Columbia River lava field, which is such an important physiographic feature of the Northwest, and in the eastern extremity of which the area surveyed lies, may be had from a brief description of its dimensions. It extends from the Bitter Root and Cœur d'Alene Mountains in western Idaho into Washington and Oregon, where it covers nearly the whole area east of the Cascades. It embraces a territory over 200,000 square miles in extent, estimated by Russell to contain 50,000 or 60,000 cubic miles of lava. (U. S. Geological Survey Water-Supply Paper No. 54, p. 54.)

Exposures in some places show it to be 4,000 feet thick, while within the area under consideration deep lateral canyons leading into the Clearwater River lay it bare for at least 2,000 feet in depth. Intervals of time between the different outflows of lava are recorded by the sedimentary and other deposits which occur between the lava sheets. These contain silicified trees and other flora which grew on a land surface formed either by the deposition of sediment or the disintegration of the lava layer on which they are found.

The land surface after the extrusion of the last lava sheet was what might be termed a bare and almost featureless plain, the range of hills to the south of Moscow standing alone in the sea of molten rock. The surface of the lava was undoubtedly similar to investigated areas of more recent date—scoriaceous, slaglike, slightly undulating, and cracked, the disfigurement being brought about by the contracting of the lava in cooling. Since this period movements in the earth's crust, together with the action of the elements, have to a great extent destroyed its uniformity.

Beginning at a point about 4 miles south of Genesee a downward movement or general subsidence of the land surface took place and brought about what is now known as the Clearwater escarpment. The huge conformable layers of lava were gradually bent in a southerly

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direction into a monoclinal fold. The dip of the layer is very abrupt, approaching in places 40 degrees. At the base of the escarpment the fold gradually flattens out and passes under the town of Lewiston. The base of another monoclinal fold, extending in an easterly and westerly direction, also passes through Lewiston. This, however, is not as pronounced as the Clearwater escarpment, the greatest dip of the layers probably not exceeding 2 degrees. Next in importance to the movements of the earth's crust in an arid region are the elements which wear away the land surface, gradually reducing it to sea level. The most active eroding agent within the area surveyed, the Clearwater River, enters a little above the southeast corner of the area and flows in a westerly direction directly along the fold or escarpment previously described. It has cut a valley a mile or more in width, the south bank of which in the east is bordered by almost perpendicular bluffs hundreds of feet in height. Westward, following the dip of the layers, the bluffs gradually decrease in height, disappearing entirely at Lewiston. The north bank throughout its entire course is about 2,000 feet high and is very steep, standing out in bold relief. It is cut by numerous canyons and small streams which drain the plateau.

With the weathering of the rock surface the small streams gradually carried away the finer material. In time small channels were eroded along the line of greatest fall, and as their courses were deepened small valleys and intervening ridges were developed. On the broad plateau rock, weathering was in advance of erosion, probably due to a light rainfall, and rock powder accumulated to a great depth. It is fine in texture and acts as a ready absorbent of water. At present a very large proportion of the rainfall is absorbed, and many of the drainage channels remain dry throughout the year. The plateau in which Genesee and Moscow are situated now stands covered with an endless succession of small valleys and ridges. The difference in elevation between the bottom of the valleys and the crests of the hills varies from 50 to 150 feet, with an occasional difference of 200 feet. They are covered, except in exposed elevations, with a deep and pervious soil. Along the Clearwater River erosion has been much in advance of rock decay. Small streams, the most important of which on the north side is the Little Potlatch, and on the south side Lapwai Creek, flow down steep gradients, cutting deep and often precipitous channels, the heads of which are gradually working inland.

Along the canyons landslides, favored by the structure of the basalt, have greatly increased the eroding power of the streams. Immense blocks give way from the precipitous walls, slide down and lodge along the slope or, occasionally, in the bed of the stream, by which they are then gradually carried away.

The physiographic features of the area may be summed up as follows: The Uniontown Plateau, a rolling prairie about 3,000 feet high, with

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an irregular "steptoe," lying south of Moscow, stands several hundred feet above all, from the highest point of which the greater part of the area may be seen. The southern boundary of the plateau terminates in a bold escarpment dissected by small streams, directly along the base of which flows the Clearwater River. South of the river lies the Lewiston Plateau, only a small part of which was included in the survey. It has an elevation in some places as great as 1,500 feet, and though less rolling than the Uniontown Plateau, it is deeply dissected. Along the Clearwater River and some of its tributaries small sedimentary deposits are formed. These occur in the form of terraces, the most conspicuous of which is the bench where the new town of Lewiston is being built, standing some 100 feet above the river.

Lithologically the rocks of the area can be divided into two sharply defined groups—an older and younger—differing widely in origin and character. The older occupies an irregular, islandlike area, several square miles in extent, in the lava field, extending from a point a little to the east of Moscow in a south and southwesterly direction, together with several comparatively small exposures laid bare in the canyons by the eroding agency of the streams which drain from the plateau. The group is made up of a large variety of rocks of pre-Tertiary origin, granites, schists, and light-colored igneous rocks predominating. No attempt has as yet been made toward systematic quarrying, and it remains to be seen whether they have any economic value.

The action of the elements has a varied effect on the different surfaces, the weathering of the mica schist and similar soft rocks being in advance of the close-grained granites. All, however, finally break down into a comparatively light-colored soil of no more than average fertility.

The younger group consists of Columbia River lava, together with the sedimentary deposits, lapilli and volcanic dust, which occur between the lava sheets. It unconformably overlies the older group, no great deposits of loose material being found between the two. At the extrusion of the last sheet of liquid magma the lava covered the entire area, with the exception of the high area previously referred to. This "steptoe" (as Russell suggests areas of this description should be termed), has since increased in extent by the gradual eroding away of the surrounding lava.

As determined by J. S. Diller, the lava is a typical basalt, containing plagioclase, olivine, and magnetite, with some globulitic base. The central portions of the layers are close grained, very dark in color, and where exposed exhibit the characteristic columnar structure, while the surface is usually scoriaceous, occasionally of a reddish color, filled with blebs, and often lacking in the characteristic structure of the true basalt. The reddish color is found in all degrees of intensity, and is due to oxidation of the iron.

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The value of the basalt as a building stone may be mentioned. Its use, however, on account of its dark color, is confined to foundations, etc. As a material for making roads it is excellent, and great quantities may be expected to be used for that purpose in the future. The rock is rich in materials containing iron, lime, phosphoric acid, and potash, and weathers into a deep, dark, uniformly textured soil of remarkable fertility.

The beds of lapilli, found between the basaltic layers, were formed by the encroaching of molten lava on bodies of water, the rock being shattered by the steam generated, or possibly the water was separated into its component parts and the explosion resulted from the ignition of the two elements. The fragments are about the size of small gravel, angular in shape, and have generally a scoriaceous or glossy surface. Volcanic dust commonly occurs in light gray layers that owe their origin to some distant volcano. The material is exceedingly fine and seems to have floated a long distance in the atmosphere, being deposited over a large area. In the layers of ash are preserved fossils of the flora existing at that time. These have been classed with known Tertiary plants, and the lava must, therefore, have been extruded during the Tertiary period, and consequently the underlying rocks of the older group must be pre-Tertiary.

Where strata of considerable thickness are found they are quite compact and may prove to be of value as a building material. Analysis of the volcanic dust by Hildebrand shows it to be richer in silica, soda, and potash than the soils of the plateau. Since evidence of showers of comparatively recent date are found, it is quite probable that plant food may have drifted in and spread over the area in the form of ash.

The sedimentary gravel, sand, and clay beds owe their origin to the surrounding mountains, from which they have been carried down by streams and either deposited along their course or in the ponds and lakes that existed over certain portions of the lava field. Like the ash, the sedimentary beds not infrequently contain fossils of plants existing at the time of deposition.

The porous layers of gravel, sand, lapilli, etc., have an important bearing on the water supply of the area, as they form ducts or passages for the movement and storage of ground water which supplies the wells.

SOILS.

The soils of the area are some of them residual and some alluvial. The former are the most important, as they are the most extensive, covering the greater part of the area. They are the result of the weathering and disintegration in place of crystalline or igneous rocks, principally trappean basalt. The trappean rocks break down into the more fertile soils. The alluvial soils are composed either of the fine sediments washed from the surrounding hills of the plateau and laid

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down in the intervening valleys or else of material picked up by the Clearwater River and carried down and left in narrow benches or terraces along its course.

Areas of different soils.

Soil.	Acres.	Per cent.
Yakima fine sandy loam	172,992	87.7
Yakima silt loam	15,936	8.1
Yakima sandy loam	6,208	3.1
Yakima fine sand	2,112	1.1
Total	197,248	....

YAKIMA FINE SAND.

The Yakima fine sand consists of a light-brown, gray, or ash-colored sand ranging from almost pure sand to a light sandy loam, having a depth of at least 3 feet and not uncommonly 6 feet, underlain by a coarse sand or gravel. It occupies small, low, level terraces or benches along the Clearwater River, and on account of its loose, incoherent nature is in every case easy to till. The soil represents the weathering of blended alluvial deposits derived from the volcanic, crystalline, and other allied rocks that occur along the Clearwater River. It is characterized by a high percentage of muscovite mica.

A special phase of this soil is a light-brown sandy loam 12 or 15 inches in depth, underlain by a lighter colored, sandier soil, which in turn runs into sand and gravel. This phase occupies a small upland mesa or terrace in the extreme southwestern corner of the area and is largely occupied by the city of Lewiston. In digging holes for telegraph poles in this area a white calcareous hardpan was encountered at a depth of 4 feet. This hardpan has a thickness of from one-half to three-fourths of an inch and offers very little resistance to the auger. When exposed to the weather for a few days it crumbles in the hands like an ordinary compacted loam. When the depth below the surface, the slight thickness of the stratum, and the soft nature of the material composing it are considered, this hardpan is of little or no consequence as affecting agriculture.

The location of the areas of this soil in a comparatively narrow valley, or perhaps more properly a canyon, between rolling plateaus, the north slope or wall of which culminates in hills in the neighborhood of 2,000 feet above the valley, gives it a protected position, inducing an early season and a prolonged summer climate—special advantages where fruit culture is the chief interest. As a result of the composition and favorable situation, when irrigation water is applied the soil gives wonderful yields, and such land with good water supply is held as high as the best lands of similar character in southern California.

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Deciduous fruits, including peaches, cherries, plums, prunes, apricots, pears, apples, and grapes, grow rapidly and, with few exceptions, bear well. Of the fruits mentioned, peaches, cherries, plums, and table grapes are said to be the most profitable. The soil is also specially adapted to the production of small fruits and truck. Cantaloupes and melons yield abundantly and are of fine quality, while many other truck crops can be made to produce two or more crops on the same ground in a single season.

The following table gives mechanical analyses of the soil and subsoil of the Yakima fine sand:

Mechanical analyses of Yakima fine sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7524	1 mile E. of Lewiston.	Fine light-brown sand, 0 to 48 inches.	1.17	0.04	0.40	0.84	26.76	38.40	29.18	4.34
7523	3 miles E. of Lewiston.	Fine sand, 0 to 40 inches.	1.36	.10	1.34	3.20	29.32	29.40	30.04	6.20
7690	Lewiston	Light sandy loam, 0 to 15 inches.	.83	.18	2.20	5.76	24.70	22.52	37.50	6.42
7691	Subsoil of 7690......	Light sandy loam or sand, 15 to 36 inches.	.12	.08	1.74	5.88	26.66	24.70	32.92	6.72

YAKIMA FINE SANDY LOAM.

The surface soil of the Yakima fine sandy loam consists typically of a friable brown sandy loam with an average depth ranging from 10 to 16 inches. There is, however, a variation in depth, color, and texture according to location. On the sharp hills, steep slopes, and points the soil is shallower, lighter textured, and lighter colored than on the more gentle inclines, the tops of broad, rounded hills, or the depressions that occur at the base of slopes, where greater amounts of organic matter have accumulated. The subsoil consists of a light-brown silty loam, much heavier and more compact and plastic than the surface, affording good storage for moisture during the dry season. The subsoil has been brought to the surface in a number of small tracts, ranging in size up to one-half acre, or possibly an acre, by side-hill plowing. When thus exposed it has the characteristic adobe tendency to crack open when dry, and consequently is less retentive of moisture than the sandy loam with which it was originally covered. Spots of this description can be easily singled out in the grain fields, the crop on such areas being lighter and maturing in advance of the rest of the field. In many places where cuts or exposures occur a very distinct line of demarca-

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tion between the surface and subsoil is seen. This line is occasionally as much as one-fourth of an inch in thickness, of a sandy nature, and of a gray or ash color. Below it the soil cracks and crumbles up cubically. The maximum amount of clay in the subsoil was encountered at a depth of from 33 to 40 inches. Below this the soil gradually gets lighter, grading into a fine sandy loam of a yellowish cast of color.

This soil type occupies a large area, and, as stated, there are some local variations. One such phase begins at a point about 4 miles south of Genesee and extends to the southern boundary of the plateau. In this area both the soil and subsoil are slightly lighter in color and in texture. This sandy nature of the soil makes it less retentive of moisture, especially along the immediate boundary line of the plateau. The crops therefore mature earlier and the harvest season sets in here a little in advance of the areas lying to the north. South of the Clearwater River another area occurs, in what is known as the Lewiston Plateau. Here the soil is lighter in color and quite sandy, even more so than in the area south of Genesee. The subsoil is a light-yellowish loam, having the same characteristics as the true type; i. e., cracking and crumbling like adobe. The rainfall here is less certain, and in seasons of shortage crop failures result. A light-colored variation is found east of Moscow and south around a portion of the area of Latah sandy loam, and in several small tracts along the Little Potlatch Creek. This area is not as fertile as the typical soil, and grain yields are lighter.

Along the canyon walls, where the soil, due to steep declivities, is quite shallow—in places there being little but bare rock or loose fragments that have broken from the more exposed places, rolled down, and crumbled over the surface—a sandy phase exists. All the areas of this description occur along the Clearwater River or its tributaries. They are of little value and are used only as pastures.

In general the surface of the Yakima fine sandy loam consists of the rolling hills and intervening depressions of the plateau. The soil has been derived from the deep weathering of trappean rocks, which are principally basalt. This weathering not uncommonly reaches a depth of 30 feet. This thoroughly decomposed rock material, with the slowly added accumulation of humus, has resulted in a dark-colored, fertile soil, the most extensive and important type in the area. An exception to the usual origin is seen in the light phases above mentioned, which owe their origin largely to igneous rocks.

Hardpan rarely occurs in this soil. A few specimens, however, were collected between Genesee and the edge of the plateau and sent to the laboratory for examination, where they were found to be the lime carbonate variety, a mixture of lime and magnesium carbonate. The very limited distribution of the hardpan and the thinness of the stratum where it does occur make its occurrence of little consequence. On the Lewiston Plateau gypsum crystals were often encountered in

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making the borings. Usually these came from a depth of about 4 feet. Alkali salts were also occasionally observed, crystallized out on the banks of the drains. As the drainage of the soil on the plateau is good, there would be very little danger of the accumulation of alkali to such an extent as to be injurious to ordinary crops, even if irrigation water should be applied.

Wheat is the staple as well as the principal crop raised on this soil. Large yields are often secured, 45 bushels to the acre being recorded. The average yield, however, is probably about 30 bushels per acre. Oats and barley also give phenomenal yields. Sometimes as much as 70 or 80 bushels to the acre are obtained, the average being above 40 bushels. While flax is not grown as extensively as the cereals, it does well and gives an average yield per acre of 15 and occasionally 20 bushels. For corn, beets (mangels and sugar beets), and some varieties of potatoes the season on the plateau is too short, frost occurring as early as September 1. Small truck gardens, to supply domestic needs, do well and furnish all the essential vegetables. Orchards, generally about an acre in extent and consisting principally of apples and cherries, furnish large quantities of superior fruit. The berries, including raspberries, gooseberries, currants, etc., thrive and yield large crops of fine-flavored fruits.

The following table shows the texture of typical samples of the soil and subsoil of this type:

Mechanical analyses of Yakima fine sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7489	2 miles E. of Moscow.	Light-brown fine sandy loam, 0 to 14 inches.	1.57	0.04	0.30	0.28	1.40	9.32	77.92	10.74
7492	9 miles E. of Lewiston.	Loose fine sandy loam, 0 to 14 inches.	2.06	.00	.08	.10	2.12	7.94	78.62	10.98
7494	5 miles N. of Genesee.	Fine sandy loam, 0 to 16 inches.	1.61	.12	.26	.18	.76	4.84	79.78	13.22
7497	¼ mile E. of Genesee.	Fine sandy loam, 0 to 13 inches.	1.83	.22	.38	.26	.62	2.98	81.64	13.72
7493	Subsoil of 7492......	Fine sandy loam, 14 to 72 inches.	.65	.00	.28	.30	1.38	10.24	81.46	6.34
7495	Subsoil of 7494......	Compact loam, 16 to 36 inches.	.50	.12	.76	.80	2.06	3.32	84.50	7.88
7499	Subsoil of 7497......	Fine sandy loam, 41 to 72 inches.	.24	.24	.34	.34	1.56	11.46	75.54	9.54
7490	Subsoil of 7489......	Loam, 14 to 40 inches.	.51	.02	.32	.26	.68	7.62	80.16	10.90
7498	Subsoil of 7497......	Brown loam, 13 to 41 inches.	.75	.10	.26	.22	.52	1.90	78.56	18.30

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YAKIMA SANDY LOAM.

The surface soil of the Yakima sandy loam is a friable brown sandy loam, with an average depth of about 24 inches. This depth, however, varies greatly, depending entirely upon the location. On hills of gentle slope the soil mantle is deep, and on the more exposed locations it is quite shallow, in a few places there being but a slight covering over the fresh rock in place. The subsoil of the greater part of the area is a light-brown loam, considerably heavier and more compact than the surface soil, grading into decomposing crystalline rock. Rock fragments are encountered occasionally in the surface and not uncommonly in the subsoil.

This soil type occupies an area of high hills, several square miles in extent, lying between Moscow and Genesee. The rocks that form the hills are crystalline, and the soil is residual and derived from these rocks. The general elevation of this area is considerably above that of the surrounding basaltic plateau, while the maximum elevation is probably 500 feet above.

The physiography of the area is comparatively rough, and on this account much of the land has comparatively little agricultural value.

In its virgin state the soil usually supports a growth of yellow pine. Some of the more favorably located areas have been cleared and planted to wheat, oats, and flax. Some fair results are reported. The average yield per acre of wheat is about 25 bushels and of flax 12 bushels. Several small apple, prune, and plum orchards have also been set out, but the apple is the only fruit giving encouraging returns.

The following table contains mechanical analyses showing the texture of the soil and subsoil of this type:

Mechanical analyses of Yakima sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7503	1 mile S. of Joel.....	Brown sandy loam, 0 to 30 inches.	2.22	0.86	1.04	0.42	1.20	5.52	79.32	11.50
7501	3 miles SE. of Moscow.	Brown sandy loam, 0 to 24 inches.	2.03	4.36	7.30	3.70	7.54	9.54	51.54	15.70
7502	Subsoil of 7501......	Brown sandy loam, 24 to 72 inches.	1.01	.00	.54	1.76	6.90	13.78	70.42	6.42
7504	Subsoil of 7503......	Brown loam or sandy loam, 30 to 72 inches.	.80	.00	.16	.20	2.96	13.80	72.48	9.64

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YAKIMA SILT LOAM.

The Yakima silt loam consists of a grayish-blue, brown, or black loam ranging from a fine sandy loam to a heavy silt loam, having an average depth of about 10 inches, and underlain by a dark-gray or bluish adobelike loam that cracks and crumbles cubically when exposed to the weather. This in turn is underlain by a lighter soil, occasionally of a yellowish cast, containing in places, especially along the main drainage lines, sand in sufficient quantities to permit the free movement of ground water.

The Yakima silt loam occupies many of the local valleys, depressions, and necks between the hills of the plateau. The surface is generally quite level.

This soil type is the result of weathering of sediment washed principally from the hills composed of the Yakima fine sandy loam, but in part it is derived from wash from the Yakima sandy loam. Where the slightest fall exists the finest sediments have been deposited, and the soil is, therefore, quite heavy and is very wet during the winter season, water occasionally standing on the surface. This is a serious drawback to cultivation, as it makes the land late and cold. Drainage, preferably by the use of underground tile drains, would in such cases be beneficial.

Wheat is the most important crop. The average yield is better on this soil than on the Yakima fine sandy loam. The crop next in importance is timothy, which does better on this type than on any other soil in the area, and gives a large cutting annually. Barley and oats, like wheat, give yields above the average. Hungarian brome-grass (*Bromus inermis*) and alfalfa also grow well. The former is rapidly being substituted for timothy on account of its drought-resisting, hardy nature and heavy yield. In the pasture tall meadow oat grass, orchard grass, meadow fescue, and redtop give good results. In general the soil is best adapted for pasturage and gives a higher grain yield than any other soil in the area, but it is not suitable for orchards or cultivated crops requiring a long growing season in which to mature, as it is the last to warm up in the spring and the first to be affected by frost in the fall.

The table on the following page gives mechanical analyses of the soil and subsoil of this soil type.

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Mechanical analyses of Yakima silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7509	1¼ miles E. of Moscow.	Gray silty loam, 0 to 11 inches.	2.25	0.50	0.80	0.48	1.76	7.20	80.66	7.48
7513	2¼ miles S. of Genesee.	Heavy silty loam, 0 to 10 inches.	1.62	.34	.74	.54	3.14	13.04	68.38	13.50
7505	5 miles N. of Genesee.	Gray silty loam, 0 to 9 inches.	4.49	.66	4.48	3.22	6.84	3.54	55.88	25.38
7510	Subsoil of 7509......	Gray silty loam, 11 to 44 inches.	1.40	.18	.66	.82	11.12	13.44	61.60	9.16
7514	Subsoil of 7513......	Yellowish-gray loam, 10 to 56 inches.	.99	.30	.70	.50	2.74	15.30	68.66	12.06
7506	Subsoil of 7505......	Light-gray loam, 9 to 46 inches.	3.41	.40	3.31	2.66	6.88	7.30	58.76	20.66

DRAINAGE.

The Yakima silt loam, situated as it is between hills and receiving all the drainage therefrom, is in some localities thoroughly saturated during the rainy season, water occasionally standing on the surface. This condition can be corrected by drainage, which already takes place in a measure through the natural water courses that traverse the several areas. The channels of these draws are usually 2 or more feet deep, but they are insufficient for thorough drainage on account of the heavy nature of the soil and the uniformly level surface and slight inclination of most of the areas. The natural drainage channels could, perhaps, be made to answer every purpose by the addition of some open ditches. Underdrainage with tile would, however, be the most satisfactory means of removing the excess of water from these wet areas.

The benefits to be derived by thoroughly draining the wet areas of this soil would be quite marked. Lands that are now cold and late and fit only for pasturage or for growing timothy could by this means be made available for the production of all the ordinary crops grown successfully on the surrounding soil—the Yakima fine sandy loam.

AGRICULTURAL METHODS.

Deep, fertile soils and a long, dry summer are the chief factors influencing the agriculture of the Lewiston area. According to the prevailing custom of the area, the fields are all thoroughly plowed, this work being generally done by means of gang plows drawn by four or

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six or even eight horses. On the main plateau the uneven surface has brought about a plan of plowing the fields in irregular patches, an effort being made to go around the hills, turning the soil wherever possible downward. This method, while it requires less work and tends to prevent washing, has laid bare the subsoil in the more exposed places. Spots of this character are locally known as "clay points." They give a light yield of grain, which ripens in advance of the rest of the crop. The difference in production is not only due to the lack of fertility, but the soil, being heavy, cracks open and is consequently much less retentive of moisture than the surrounding soil, and the crop is apt to suffer from drought. Orchards and truck gardens require a more thorough tilling of the soil than the grain and are consequently given more attention. The lands are thoroughly plowed during the winter and then given thorough cultivation during the summer, an effort being made to keep the soil free from weeds or grass. Orchard grass or grain between the trees is considered more injurious than beneficial.

Fallowing—that is, plowing lands thoroughly and allowing them to lie idle a year—is a method which, though of comparatively recent introduction, has gained great favor as a means primarily of checking the growth of foul weeds, principally wild oats, cockle, and Chinese lettuce, which get so thick as to greatly reduce the quantity and injure the quality of the grain crops. Late in the spring, when the weeds are well started, the lands are plowed, rolled, and harrowed, and during the summer an effort is made to sprout and kill all the injurious seed in the surface soil. The increase in yield after a year's summer fallowing is also encouraging, so much so that in many cases lands are being fallowed every third and fourth year, and in some cases even every other season, although it is said that fallowing every fifth year is sufficient to keep the weeds in check. Winter wheat is generally planted on the fallowed soil, the ground being too rich for barley or oats, which commonly grow so tall and rank as to lodge. They are sown to greater advantage as a second or third crop.

The following rotation in the grain fields is favored by many: (1) Winter wheat, (2) barley or oats, (3) barley, wheat, or oats cut for hay, (4) fallow; or (1) winter wheat, (2) wheat, (3) barley or oats, (4) fallow. Timothy, clover, and other grass or pasture lands are occasionally rotated with grain and give very encouraging returns. Alfalfa has also been turned under. The results were good, but the practice is as yet too new to say whether the end justifies the means. Flax is introduced into the grain rotation in some places and in a few cases is sown as the principal crop.

Drills are used to seed the grain field, and the crops are harvested with either a binder or a header. The former, notwithstanding the fact that it requires more time and is more expensive to operate, is generally considered the better and more economical in the long run,

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as the grain can be harvested and shocked before it is thoroughly ripened, thus insuring it against serious damage by wind or rain. There is also less loss in handling the tied bundles than the loose straw, and a smaller number of heads drop and are lost.

The combined harvester, drawn either by traction engine or by horses, can not be used to advantage on the Genesee and Moscow plateaus, as the hills are too steep. There are, however, sections on the south side of the Clearwater River where traction-engine outfits are used to advantage, and in such places steam plows also facilitate the tilling of the land.

The grain is usually thrashed by an ordinary separator run by steam, though a few horsepower machines are used. The grain is sacked in bags holding a little over 2 bushels, and is then hauled to storage houses or to the nearest railroad siding.

Wheat, barley, oat, and timothy hay are cut with the ordinary mower, the grain hay being cut while the head is yet in the dough. Cut at this stage the straw makes better fodder than when mature. Some grain hay for local consumption is also cut with the binder. The hay when cut is allowed to dry and is then gathered into cocks with horse rakes. After curing it is collected in stacks convenient to the baling places. Considerable hay is baled for shipment.

Where fruit is the money crop the orchards are given much attention, no little care being exercised to keep the trees healthy by proper pruning and spraying. Grapes are also carefully cultivated. They are well pruned each fall and thoroughly dusted with sulphur in the spring to prevent the mildew. All fruits and melons are picked when mature and, after being crated, go to supply the local and near-by markets. Some is shipped into Montana, where fancy prices are obtained. The market for green fruit is very good, and only a very small proportion of the crop is dried.

The rainfall on the upland, excepting the steep canyon walls where most of the rain runs off, is adequate for the production of all the ordinary crops. Irrigation is practiced only along the Clearwater River. The water is either taken from the river by gravity ditches or by pumping, or is obtained from springs that issue from the basalt bluffs. The soils being sandy and free from injurious salts, irrigation is a simple matter, water being applied with impunity. At present there is also considerable land along the river that could be put under water without much outlay and converted into valuable farms suited to the production of all the ordinary crops grown in that vicinity.

The soils in their original state being very fertile, the want of plant food has not as yet been seriously felt. The gradual depletion of the essential elements of plant food by continuous cropping is, however, inevitable, and its progress can be checked only by rotation, fallowing, and fertilization. The diminution in yield is already apparent to the

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observer, who also notes the increase in crop following a year's summer fallow. The fallowing, while killing the weeds and conserving the moisture, also gives the soil an opportunity to weather and store up a greater amount of available plant food for the ensuing crop.

Beneficial results were reported from the application of stable manure and lime. The use, however, of either stable manure or commercial fertilizers has not generally been given any serious consideration. A custom of burning the straw stacks and disposing of the manure in any way is prevalent. This condition should be changed. The importance of conserving plant food whenever possible is a matter of grave importance and should demand the serious attention of the farmers even of so naturally fertile a country as that comprised in the Lewiston area.

AGRICULTURAL CONDITIONS.

Soils of remarkable fertility, admirably adapted to the crops which they are called upon to produce, good transportation facilities, and the occupancy of an energetic class who generally own the land they farm have in a comparatively short time converted the rolling, grass-grown prairies of the Lewiston area into prosperous, well-fenced, and often well-improved farms. The area, lying within the southeast corner of the justly famed Palouse wheat district, enjoys part of its enviable reputation for wheat production. This Palouse district produces annually about 50,000,000 bushels of wheat, to which output the Lewiston area contributes materially. The prosperity which the area enjoys can not in every case be measured by the farm buildings. Here and there are large barns and commodious dwellings, but the country is too new for one to expect the most striking evidences of prosperity on every hand. The old, more or less temporary structures are gradually giving way to more stable and commodious buildings, and it is only a question of time when the area will be dotted with comfortable dwellings and ample barns and sheds for the proper housing of stock and other products.

The size of the farms varies from a few acres, as in farms situated along the Clearwater River and in the immediate vicinity of the town, which are irrigated and devoted to horticulture and trucking, to 1,000 acres, as in the wheat farms on the uplands. With the increase in population, however, the large tracts are gradually being subdivided, giving place to smaller farms under more intensive culture. This tendency is viewed with much satisfaction by those most interested in the future of the country. The small farm, highly cultivated, diversified farming, and the adoption of modern methods promise the surest prosperity of a stable agricultural industry. The advantages to be derived by a thickly settled community along social, educational, and other lines are important.

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Land values depend on quality, adaptability, and proximity to market and transportation facilities. Wheat land in the Genesee and Moscow plateau is held at from $15 to $65 per acre, the average being probably about $35, while land along the Clearwater River, under irrigation and adapted to horticulture, is held as high as $150 an acre; and when in trees often much higher.

On the greater number of farms the work throughout the year, except during the harvest season, is done by the farmer, with possibly the assistance of one or two outside hands. This number is, however, exceeded on the large estates, where most of the work is done by the hired help. The wages paid run from $15 to $25 per month, with board in addition. During the harvest season the amount of work is greatly increased, extra help is required, and wages go up to $2 or $3 a day with board. The wages depend upon the nature of the work and are quite uniform throughout the grain belt.

Wheat is the principal crop, and to that product is due much of the area's rapid advancement. The other grains—barley, oats, and flax—are also raised in large quantities and form an important part of the farmer's resources. The grasses, though at present occupying a high place among the products of the area, will in the future, with the increase of dairying and stock raising, become even more important. Timothy is grown with great success, principally on the level valleys, and large crops of choice hay are cut and baled annually. The Russian brome grass, a forage plant recently introduced, bids fair to become a very important crop, as it is rapidly gaining favor with the farmers. It is very hardy, makes good pasturage, and when allowed to grow for hay gives large yields of superior quality. Orchard grass, redtop, tall meadow oat grass, alfalfa, rye grass, and meadow fescue also grow well and make good pasturage and hay.

Corn, pumpkins, and other crops sensitive to cold and requiring a long time to mature have been tried by many. The season is, however, too short to allow a perfect development except in a few especially favored locations, and as a result few attempts are made to grow these crops commercially.

Orchards of peaches, apples, plums, cherries, pears—in fact, of all the deciduous fruits—have been set out along the Clearwater River. The trees grow fast, bear well, and produce abundantly. Several small vineyards have made a good showing and are indicative of the results that may be expected from this fruit in the future. Cantaloupes and melons are also deserving of mention. On the upland orcharding is not carried on commercially to the exclusion of other products of the farm. In the vicinity of the ranch houses, in many cases, from 1 to 4 acres are devoted to fruit and berry culture. Apples and cherries do well, but the season is too short for the proper development of most of the other fruits. All varieties of berries,

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excepting possibly blackberries, grow fast and give very large yields of superior fruit with comparatively little attention. Small truck gardens in the vicinity of the house furnish the country and some of the city populace with most of the ordinary vegetables during the summer. The deficiency and also the spring and fall demand is filled by the products of land in the vicinity of Lewiston, which, on account of its low lying and sheltered position, is favored with a warmer climate, and is thus able to produce early and late vegetables as well as vegetables which can not be grown successfully on the uplands.

Since the curtailment of the ranges by the taking up and farming of the public land within the area, considerable interest in the raising and feeding of small herds of stock on the home farms has been developed. The returns from raising horses, cattle, sheep, and hogs are encouraging, and no little attention is being paid to the improvement of the breeds. In future the output not only of stock but also of dairy products may be expected to greatly increase. Flocks of poultry also add to the annual income of the farmers.

The roads, which generally follow the valleys or depressions in the Moscow and Genesee Plateau, are, during the winter or rainy season, very muddy and all but impassable, while in the summer they are extremely dusty. In the lowlands, or in the area south of the Clearwater River, the roads, while just as dusty if not dustier in summer, are much better in winter. This difference is due to the difference in rainfall, the sandier character of the soil, and the topography, which allows the roads to be so constructed as to attain better drainage. The great advantages offered by good roads, as well as the disadvantages and menace to a community in poor roads, are too well known for comment. The untoward conditions in the area can, and it is safe to predict will, be remedied. The underlying rock is hard, and when crushed it breaks with a good fracture, furnishing excellent as well as convenient road-building material. This fact is clearly demonstrated wherever the basalt has been used for macadamizing, as in the streets of Moscow and Genesee.

In the northeastern part of the survey there is a forest consisting of spruce, tamarack, and white and yellow pine. All the merchantable lumber has been cut, but cordwood is plentiful, and large quantities are used annually to supply the local fuel demand.

The area is well supplied with building material. Logs are floated down to the mills at Lewiston from the headwaters of the Clearwater River, where forests of choice white pine, spruce, cedar, and other valuable trees exist. Sawlogs are also shipped to Moscow and there cut into dimension lumber. Basalt has been quarried and used to some extent as building stone, principally for foundations. Good bricks are also made from material furnished by the Yakima fine sandy loam.

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The domestic water supply of Lewiston is pumped from the Clearwater River, while that of Moscow is obtained from artesian wells. In the country and small towns water is furnished by wells and springs. The wells are not very deep, and occasionally run dry during the summer. A good supply of water may be obtained by drilling wells into the porous material or sedimentary beds lying between the layers of basalt.

The area is well supplied with transportation facilities. Two railways, the Oregon Railway and Navigation Company and the Northern Pacific Railroad, have branch lines entering Moscow, Genesee, Lewiston, and several smaller places. Boats run up the Snake River as far as Lewiston, carrying both freight and passengers. Country mail routes have been surveyed, and a number of the farmers are already enjoying the advantages of rural delivery.

Moscow, situated in the northern part of the area, is the county seat of Latah County. It has a population of about 3,000, and is the home of the State University, which offers many educational advantages. Lewiston, a growing city in the extreme southwestern corner of the area, is the county seat of Nez Perces County, and has a public library and a normal school. Genesee, which is midway between Lewiston and Moscow, is of importance as a wheat-shipping point. It is estimated that the surrounding region ships annually from Genesee approximately 1,500,000 bushels of wheat, the greater part of which comes from within the limits of this survey. As Moscow, Lewiston, and the several freight-receiving stations are also shipping points, the amount mentioned is probably not more than one-third of the wheat produced in the area surveyed. These towns are also important as home markets and as the residence of merchants who buy and handle the country produce.

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SOIL SURVEY OF THE WALLA WALLA AREA, WASHINGTON.

By J. GARNETT HOLMES.

LOCATION AND BOUNDARIES OF THE AREA.

The area surveyed occupies the south central part of Wallawalla County, Wash. This county is in the southeastern part of the State and is bounded on the east by Columbia County, on the south by Umatilla County, Oreg., on the west by Klickitat, Yakima, and Franklin counties, Wash., and on the north by Franklin County, Wash. An

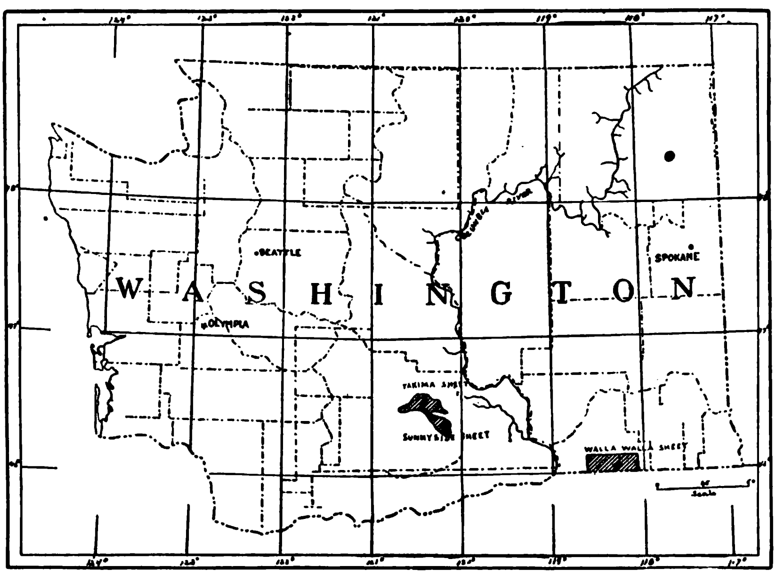

FIG. 22.—Sketch map showing areas surveyed in Washington.

area 8½ miles north and south by 24 miles east and west was mapped. The area comprises a part of townships 6 north and all of townships 7 north, in ranges 34, 35, 36, and 37 east. This area contains the city of Walla Walla, and includes all the lands under cultivation devoted to the growing of fruit and vegetables in that vicinity, and a representative part of the wheat lands of Wallawalla County. The eastern end of the area includes a part of the compact foothill lands west of Blue Mountains, while in the western end occur the fine sandy hill lands which border the Columbia River. (See fig. 22.)

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HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Prior to 1836 there was no attempt whatever to grow crops of any kind in this region. A few trading posts of the Hudson Bay Company were then the only settlements of white men in this northwestern territory. In that year, however, came the usual forerunner of civilization in the West, the Indian missionary. Dr. Whitman, with a small band of missionaries, settled on the Walla Walla River about 7 miles west of where the city of Walla Walla now stands. Garden truck and fruit trees were planted in a small way. The hostility of the Indians and lack of markets, however, prevented any real agricultural development until several years later. In 1853 the Territory of Washington was set aside, including the present States of Washington, Idaho, and the part of Wyoming and Montana west of the Rocky Mountains. The garrison at Walla Walla was established in 1856. In 1857 a small garden was planted at the garrison, which did remarkably well. The following year an experiment was made in growing barley—80 acres, which yielded 50 bushels per acre, being planted in the vicinity of the present fort.

This success encouraged the few squatters near the garrison and finally led to a treaty being made with the Indians (1859), whereby the region, including Walla Walla, was thrown open for settlement. Only a small amount of grain was grown this year, however, as the garrison afforded the only market, but it was demonstrated that grain could be grown in amazing quantities, so that quite a number of settlers came in and took up land in the valleys along the small streams.

In 1860 occurred what has always been the greatest factor in the settlement of our frontier—the discovery of gold. A party of prospectors brought out a small amount of gold dust from the North Fork of the Clearwater in the Palouse country. This discovery caused a mad rush of gold seekers—all of whom bought their supplies at Walla Walla—to the new region, and a ready home market was created for all farm produce. The small valleys, which were then considered the only land of agricultural value, were rapidly settled and farmed to grain and hay. By 1867 the rush to the mines had somewhat subsided, the quantity of grain grown had increased, and farm products were grown in the vicinity of the mines, so that the farmers of Walla Walla were again seeking a market. This year a small shipment of wheat and flour was made by teams to Wallula, on the Columbia River, and by steamboat from there to tide water. The receipts from these shipments were very satisfactory, notwithstanding the high freight rate from Walla Walla to Wallula. About this time began the agitation for a railroad from Walla Walla to Wallula. A company was formed and surveys made, but nothing was actually done upon the building of the road until 1874, when it was built from Wallula as

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far as Touchet. The following year it was completed to Walla Walla. Although this road was a primitive, narrow-gauge affair, it hauled hundreds of tons of wheat to Wallula each year. From this time on the growth of agriculture in the valley has been gradual and substantial. Soon it was found that the hills grew fully as good grain as the small valleys, and that these valleys were well adapted to the growth of alfalfa, garden vegetables, and fruit. In a short time the road connecting Walla Walla and Wallula was absorbed by the Oregon Railway and Navigation Company and converted into a standard-gauge road. This completed the road to tide water, lessening greatly the cost of shipment. As transportation facilities increased and improved machinery lessened the cost of production the land cultivated to grain has gradually encroached on the hill land formerly devoted exclusively to grazing, until at the present time almost all the land in Wallawalla County, except some of the steepest hills and the sandy land in the western part, is now sown to grain. No more than five years ago all of the land in the northwestern part of the area mapped was open range, but the homesteader has now brought all this under fence, and although some of the slopes are very precipitous it is all farmed to grain.

In the last few years small fruits, vegetables, and berries have been the principal crops of many of the small farmers in the small valleys near Walla Walla. During last year shipments of such produce amounted on an average to about two carloads a day.

CLIMATE.

Southeastern Washington is a semiarid, temperate region. The mean annual temperature of Walla Walla is 53° F. The recorded extremes are 113° F. above zero on August 10, 1898, and 29° F. below zero in January, 1875. The latter record was made before Walla Walla had a regular Weather Bureau station, and may not be correct.

The normal annual rainfall is 17.7 inches, which is a little more than that of the wheat regions of the San Joaquin Valley, California. Walla Walla is about the center of the area mapped, and the records may be taken as representing average conditions. Near the mountains on the east the rainfall is greater, and in the western end of the area, 2 miles west of Walla Walla, it is considerably less. Although no records have been kept in these places, the difference is evident in the yields of grain. A total failure of crops on account of drought, in the valley, has never been reported. The early records of the county show that in 1869 there was a drought, but even then there was half a crop grown. The lowest annual rainfall recorded is 11.80 inches, which occurred in 1890; the greatest was in 1885, when 22.27 inches fell. Appended is a table showing the normal monthly and annual

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temperature and precipitation for Walla Walla. No other stations are maintained by the Weather Bureau in the area.

Normal monthly and annual temperature and precipitation.

Month.	Walla Walla.		Month.	Walla Walla.	
	Temperature.	Precipitation.		Temperature.	Precipitation.
	° F.	Inches.		° F.	Inches.
January	31.9	2.30	August	73.2	.41
February	37.9	1.53	September	62.6	.90
March	45.4	1.82	October	52.8	1.52
April	53.2	1.79	November	42.6	2.07
May	60.4	1.66	December	37.1	2.17
June	65.7	1.27	Year	53.1	17.74
July	74.3	.30			

A good percentage of the winter precipitation is in the form of snow, enough of which falls to afford sleighing for at least a part of each winter. Hot winds sometimes visit the valley in June and injure the wheat in its later stages, and occasionally winter freezes are severe enough to kill fall-sown wheat. These occurrences, however, are the exception, and the climate on the whole is excellent for the production of the cereals.

PHYSIOGRAPHY AND GEOLOGY.

What is usually known as the Walla Walla Valley is one great expanse of rolling hills. In no place is there any considerable area of level land, except immediately along the small streams, which in some instances have cut out level valleys a mile or so in width. Immediately south of Walla Walla and also to the northeast of the city these hills are gently rolling, affording fields that are easily cultivated, but the foothill land in the eastern part of the area and the country in the western and northern parts is composed of very high, steep hills, which in many places are very difficult to cultivate. The small valleys are sufficiently level to readily allow irrigation. Although the country is very broken and hilly at the present time it was once the comparatively level bottom of the ancient Lake John Day, which at one time covered what is now northeastern Oregon, southeastern Washington, and western Idaho. Subsequent elevation and folding of the rocks lying in the lake bottom, due to volcanic agencies, have given to the country its present physiographic features.

Mill Creek, one of the principal streams of the area, rises in the Blue Mountains in Oregon, southeast of the area, and enters Washington in the southeastern corner of the fractional T. 6 N., R. 37 E., and flows in a northwesterly and westerly direction until it empties into the Walla Walla River in T. 7 N., R. 35 E. It is this stream

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which flows through the city of Walla Walla and furnishes water for the city and for the greater part of the present irrigation.

About 5 miles east of Walla Walla two streams, called, respectively, Garrison and Yellow Hawk creeks, leave Mill Creek. South of these Russell, Clark, and Cottonwood creeks flow in a general northwesterly direction to the Walla Walla River, in T. 7 N., R, 35 E. All these smaller creeks are fed by springs, some of which flow large quantities of water. Walla Walla River enters the area from the south, in T. 6 N., R. 35 E., and flows northwest until joined by Mill Creek, after which the course is nearly due west to the Columbia River, 35 miles west of Walla Walla. South and west of the Walla Walla the Little Walla Walla River and Mud Creek enter from Oregon and flow northwest into the Walla Walla. Dry Creek rises in the northeastern part of the area, flows north to several miles north of the district surveyed, and again enters the area in T. 7 N., R. 35 E., from which point it flows southwest to the Walla Walla River. All of these streams contain water the year round, not all of which is at present utilized.

All of that part of the area south of Dry Creek is underlain by water-bearing gravels at a depth of from 20 feet in the valleys to 100 feet in the hill lands. North of Dry Creek a solid mass or sheet of basalt is encountered at about the same depth as the gravel beds south of this stream. No water has yet been procured in this northern region.

The whole area and the regions beyond give evidence of succeeding periods of volcanic activity. The gravel in the stream beds and that dug from wells throughout the valley is all of volcanic rock. The impervious layer of rock encountered north of Dry Creek is an old lava flow. West of the area, toward the Columbia River, are found lava flows of much more recent date, and volcanic ash, deposited along with products of erosion, forms a noticeable percentage of all of the soils.

Granite bowlders, often weighing a ton, are found scattered erratically over the area, sometimes on the top of the hills and again along the sides of the hills. Some are entirely buried, while others outcrop, but all are angular and only slightly weathered. The nearest granite mountains are miles away, so that these bowlders must have been brought into the area by icebergs when the country was covered by water. Many of the bowlders are covered with a lime deposit, showing that they remained a long time under water.

SOILS.

The soils of the area mapped are remarkably uniform. The soil mantle of the whole county was deposited at the bottom of a great lake, and at the time of deposit the soil material was virtually the same throughout. Variation in rainfall and erosion are responsible for the present differences.

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Five types of soil were recognized and mapped, the extent and relative importance of which are shown in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Yakima sandy loam	64,896	50.55	Yakima gravelly loam	10,048	7.83
Yakima fine sandy loam	26,688	20.79	Yakima loam	3,392	2.64
Walla Walla loam	23,360	18.19	Total	128,384	....

YAKIMA SANDY LOAM.

The Yakima sandy loam is a friable grayish-brown sandy loam 6 feet or more in depth. The sand in the soil is very fine, with little clay, giving to the soil a characteristic ashy appearance. Occasional bands or pockets of volcanic ash and fine sand occur throughout the surface 6 feet. It is easily cultivated and retains moisture well. In some places a compact layer, at from 2 to 6 feet below the surface, somewhat resembles a hardpan. This layer is very soft and boggy after a season of rain, but as it dries out it gradually becomes harder until it is almost as hard as a calcareous hardpan. Examination shows it to contain a small quantity of alkali, which is no doubt the cause of the compactness of the soil. This hardpan, however, does not affect any considerable area, for in most cases where it does occur it is not near enough the surface to influence the crops grown.

The Yakima sandy loam occupies all of the hill area and the most of the area in the small valleys around Walla Walla, and reaches north and south to the limits of the survey. It represents a zone extending at a distance around the base of the Blue Mountains. The difference in texture between this soil and the fine sandy loam on the west and the more compact loam to the eastward is mainly the result of the difference in rainfall of the three regions. Toward the east, at the base of the Blue Mountains, the rainfall is much greater and weathering has been greater than at Walla Walla, and consequently a greater percentage of the sand has been converted to clay and here is found a compact sandy loam. To the westward the rainfall is much less than at Walla Walla, so that the original lake sediments are very little altered. Since the rainfall diminishes gradually as the distance from the mountains increases, these three soils gradually blend into each other, making the boundaries zones rather than well-defined lines of contact, as is often the case in alluvial soils.

The greater part of the Yakima sandy loam occurs as steep, rolling hills. In the immediate neighborhood of Walla Walla, however, to the south, east, and northeast, these hills are only slightly rolling and not difficult to cultivate, but farther north and west, and next the Walla Walla loam on the east, the hills are very steep. In many places the

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narrow valleys along the streams are of this same soil, which has merely been leveled down and shifted about from one side of the valley to the other by the stream as it has worn its way through the hills.

Owing to the prevailing hilly surface and the open, porous texture of the soil, the greater part of this type is well drained. A few small areas along the streams would be benefited by drainage, but these are very limited in extent.

As originally deposited in the lake bottom this soil came principally as the product of erosion from the surrounding high mountainous region. Mixed with this was a considerable quantity of volcanic ash.

Nearly all of this soil contains a small quantity of alkali. In most places this is not enough to affect crops, but in the areas along the streams, where the ground water has stood near enough to the surface to allow evaporation to take place continually, the alkali has accumulated in sufficient quantity to materially injure crops. Compared with the total acreage, however, the percentage of alkali soils is very slight.

Nearly all the Yakima sandy loam is sown to wheat or barley, which are the main crops of the country. Wheat is grown most extensively and yields an average of about 30 bushels per acre, while barley produces an average of 40 bushels per acre. Alfalfa is grown in places along the streams and yields well, but this soil may be said to be especially adapted to wheat and barley.

The following table gives mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Yakima sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6683	No. 12–40, sec. 8, T. 7 N., R. 35 E.	Sandy loam, 0 to 48 inches.	0.91	Tr.	0.10	0.14	3.88	44.24	46.28	4.38
6684	No. 6–40, sec. 25, T. 7 N., R. 35 E.	Sandy loam, 0 to 54 inches.	.88	0.10	.16	.34	2.68	39.60	52.08	4.60
6867	No. 15–40, sec. 34, T. 8 N., R. 35 E.	Sandy loam, 0 to 72 inches.	.82	.22	.64	.72	4.20	17.22	70.72	6.20
6865	NE. corner sec. 18, T. 7 N., R. 37 E.	Sandy loam, 0 to 40 inches.	2.21	.04	.16	.18	3.06	17.26	70.62	8.68
6863	NW. corner sec. 16, T. 7 N., R. 37 E.	.....do	2.16	.08	.42	.26	2.40	18.68	69.04	9.04
6864	Subsoil of 6863	Sandy loam, 40 to 72 inches.	.74	.10	.34	.16	1.94	18.88	70.62	7.96
6866	Subsoil of 6865	.....do	.64	.02	.08	.10	1.58	12.22	76.88	9.00

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WALLA WALLA LOAM.

The Walla Walla loam is a compact, sticky brown to dark-brown loam, inclined toward a sandy loam, 3 feet in depth, underlain by a sandy loam similar in texture to the subsoil of the Yakima sandy loam. The roads of this district are hard and the fields often bake and plow up in great clods.

As has been before stated, this soil is found occupying the higher hill region in the eastern part of the area. The hills here are very high and steep, merging gradually into the Blue Mountains. The same soil extends an undetermined distance eastward. The steep slopes afford good drainage, so that even in the rainy seasons the soils are well drained.

This soil was formed in the same way as the Yakima sandy loam, the present difference being due mainly to their geographical position in respect to the mountains.

No part of this soil contains harmful amounts of alkali salts. This is due to the greater rainfall and absence of low, level stretches where the alkali might accumulate.

Like the Yakima sandy loam, the Walla Walla loam is sown almost exclusively to grain, of which it produces more than the first-mentioned soil, averaging about 35 bushels of wheat and 50 bushels of barley per acre. This increased production is due partly to the greater rainfall and partly to the heavier nature of the soil. It is the best grain land in the area.

The following table gives mechanical analyses of soil and subsoil of this type:

Mechanical analyses of Walla Walla loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6852	SW. corner sec. 23, T. 7 N., R. 37 E.	Compact sandy loam, 0 to 40 inches.	3.68	0.30	0.36	0.42	3.80	14.40	69.10	11.28
6856	SW. corner sec. 3, T. 6 N., R. 37 E.	Sandy loam, 0 to 30 inches.	1.96	.62	.92	.38	1.82	11.48	70.98	13.60
6854	SE. corner sec. 27, T. 7 N., R. 37 E.	Compact sandy loam, 0 to 50 inches.	4.27	.40	.44	.26	1.94	12.14	68.40	16.26
6853	Subsoil of 6852......	Sandy loam, 40 to 72 inches.	2.24	.18	2.90	.30	4.64	25.70	61.20	4.80
6855	Subsoil of 6854......	Compact sandy loam, 50 to 72 inches.	.91	.40	.70	.36	2.00	13.00	71.72	11.72
6857	Subsoil of 6856......	Sandy loam, 30 to 72 inches.	.68	.88	1.52	.78	2.54	12.24	66.38	14.08

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YAKIMA FINE SANDY LOAM.

This is a whitish to gray fine to very fine sand, having the properties of a sandy loam. It is locally known as "light land," as when it is plowed it is very loose and ashy. In most places the soil is 6 feet or more in depth, but occasionally small areas are underlain at a depth of 3 feet by a sort of hardpan, which marks the average penetration of the rain water.

This soil is found wholly in the western part of the area and extends across the hills and valleys, as the Yakima sandy loam does to the eastward. The hill land is well drained, but a part of the area along the Walla Walla River needs drainage. Like the soils already described, it is derived from sediments of the ancient Lake John Day, with admixtures of volcanic ash.

The hill lands all contain a small percentage of alkali, but there is not enough seepage there to concentrate this in harmful quantities in any locality. Along the river, however, the greater part of the Yakima fine sandy loam is alkaline and is at present used only as pasture.

Nearly all the hill lands are now sown to wheat, but the soil produces less than the lands farther east. Twenty bushels of wheat per acre is a fair average for this section, while barley usually produces about 30 bushels per acre. Lightness of the soil and decreased rainfall are the causes of this lessened yield.

The following table gives mechanical analyses of soil and subsoil of this type:

Mechanical analyses of Yakima fine sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6859	W. side No. 12-40 sec. 15, T. 7 N., R. 34 E.	Fine sandy loam, 0 to 60 inches.	0.97	0.08	0.34	0.36	4.60	19.08	69.80	5.72
6862	Center sec. 31, T. 7 N., R. 34 E.	.....do..............	.38	.02	1.14	.78	5.80	27.56	58.06	6.46
6860	SE. corner No. 8-40 sec. 29, T. 7 N., R. 34 E.	.....do..............	.89	.04	.38	.54	3.98	9.46	77.86	6.96
6858	NE. corner No. 14-40 sec. 34, T. 7 N., R. 34 E.	Fine sandy loam, 0 to 36 inches.	.84	1.10	3.58	2.36	8.00	14.06	60.96	9.46
6861	NE. corner No. 10-40 sec. 16, T. 7 N., R. 34 E.	Fine sandy loam, 0 to 60 inches.	.33	.24	.92	.80	3.60	8.46	68.58	16.22

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YAKIMA LOAM.

The soil of the Yakima loam consists of a dark-brown to black friable loam 3 feet deep, underlain by a sandy loam or gravelly loam. It is found only along the small streams of the area, where it exists in small level areas. It is usually sufficiently well drained to allow the growth of vegetables, small fruits, or alfalfa, although in a few places the water comes within 4 feet of the surface. It has been formed in parts of the valleys subject to overflow and is the finer sediment from the streams mixed with organic matter from decaying vegetation.

Very little of the soil is alkaline, the only place being along Dry Creek, in the northwestern part of the area.

The Yakima loam is nearly all planted to vegetables, small fruits, and alfalfa, producing fair crops of all. It may be said to be best adapted to these crops.

The following table gives mechanical analyses of soil and subsoil of this type:

Mechanical analyses of Yakima loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6686	Center sec. 28, T. 7 N., R. 36 E.	Black, sticky loam, 0 to 36 inches.	3.37	0.50	1.12	1.32	8.10	23.38	55.62	10.22
6687	Subsoil of 6686......	Yellow sandy loam, 36 to 72 inches.	.53	6.64	5.20	1.86	3.40	18.90	46.90	17.06

YAKIMA GRAVELLY LOAM.

The Yakima gravelly loam is a brown loam with a depth of 3 feet, containing a high percentage of rounded, waterworn basalt gravel, ranging from one-third of an inch in diameter to the size of a man's head. Below the surface 3 feet the percentage of gravel increases and the soil is closely cemented together.

This soil is found only in the level valley portions of the area and skirting the streams, the largest areas being in the immediate vicinity of Walla Walla. The surface is comparatively level, being broken only by small stream beds. It is always well drained.

The soil is the direct result of the streams along which it occurs. Erosion has worn away the sandy-loam soil that covers this portion of the valley, exposing the gravel beneath. This has received a small amount of sediment from the streams and thus becomes a gravelly loam. None of this soil contains harmful amounts of alkali.

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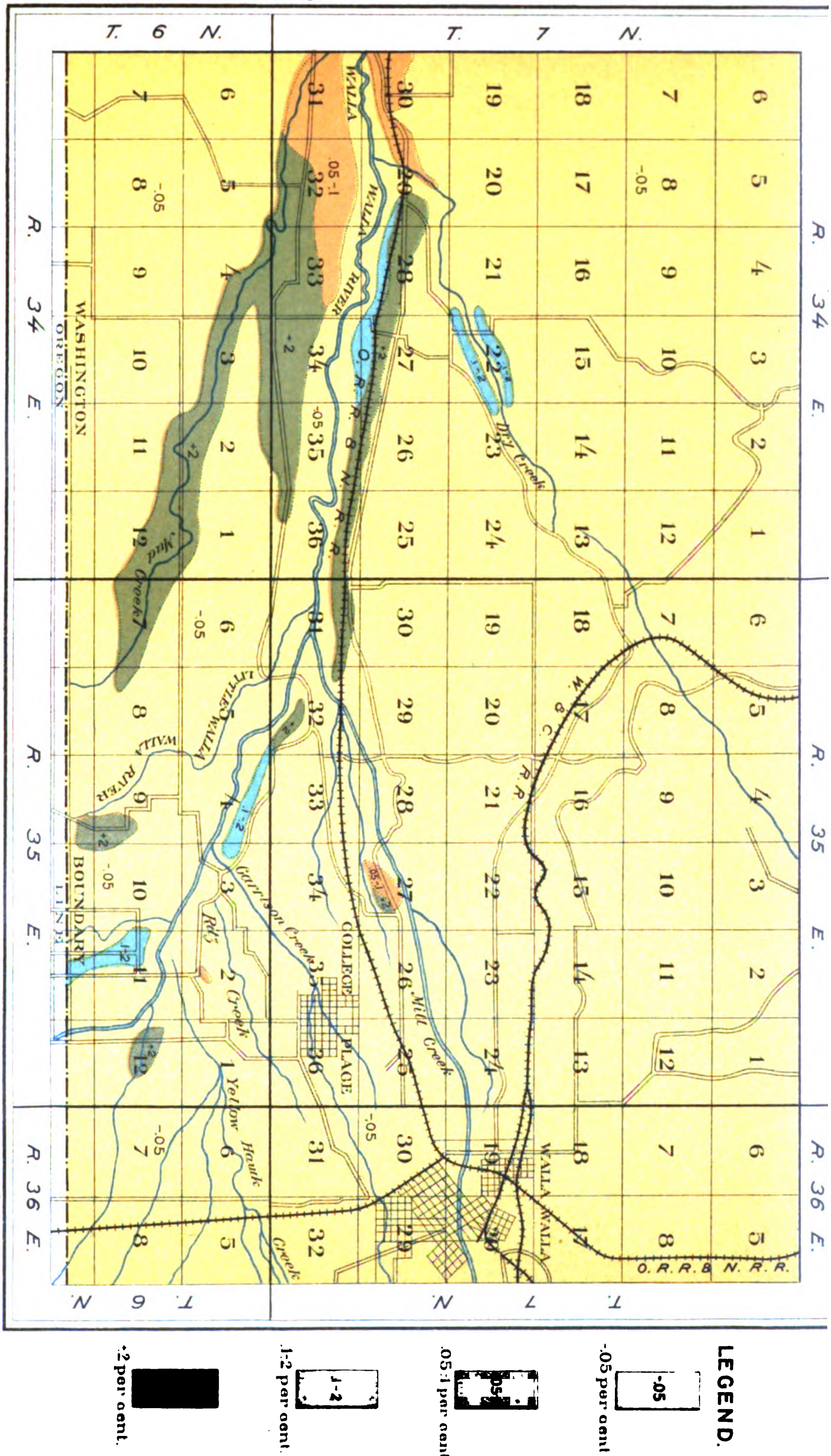

BLACK ALKALI MAP, WALLA WALLA SHEET

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Only about 30 per cent of the soil is cultivated. It is planted to vegetables and small fruits that require irrigation. These crops yield well. The remainder of the soil, usually along the streams, is used for pasture land. Where the percentage of gravel is not so great as to make cultivation impracticable the gravelly loam, with the aid of irrigation, is well adapted to vegetable and small-fruit growing.

The following table gives a mechanical analysis of this soil:

Mechanical analysis of Yakima gravelly loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6685	NW. corner No. 11-40, sec. 19, T. 7 N., R. 36 E.	Gravelly loam, 0 to 12 inches.	1.50	3.12	6.26	3.92	11.50	21.70	44.34	7.88

IRRIGATION.

Irrigation in the vicinity of Walla Walla is confined to the small valleys, as the hills are too rough to permit of any practicable method of applying water. Even of the valley land but a small percentage of that nearest Walla Walla is irrigated. This is planted principally to truck and fruits. Alfalfa, which is grown extensively upon the bottom lands, is not generally irrigated, although a few farmers have begun to irrigate this crop, with fair results in increased yields.

There are in all about 2,500 acres of irrigated land. The water for this irrigation is taken from the creeks in very small ditches, which are owned by the irrigators individually. In places where only small plots are to be irrigated water wheels are used to lift the water onto the land.

With a careful distribution of the water the irrigated area along the creeks could be increased about one-half. Farther west in the area, along Walla Walla River, much water runs to waste that might be used for irrigation. In that place there are several small ditches, but these are out of repair and little used. Much of the soil there is alkaline, the reclamation of which would be greatly facilitated by the liberal application of irrigation water, and would be assured if this was supplemented with thorough drainage.

Altogether there are fully 5,000 acres of land within the area mapped that could be economically irrigated.

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ALKALI IN SOILS.

Toward the western part of the area, along the Walla Walla River and Mud and Dry creeks, the land is alkaline, some of it so much so as to be practically abandoned. Even in the small valleys about Walla Walla and in some places on hillsides small patches of alkali are seen, but these patches are limited in extent, and the percentage of alkali present in the soil is very low. The nearest alkali in sufficient quantity to be mapped is about 3 miles west of Walla Walla, in sec. 27, T. 7 N., R. 35 E. West and south from this point small areas of alkali are found along the streams.

All the soil of the valley has traces of alkali, and these areas, when the amount is harmful, are caused by the localizing and concentration of the alkali by the water, which takes up a small amount of salt only to deposit it at the point of evaporation. Thus an accumulation of alkali is the usual accompaniment of a high water table. Small alkali patches at the base of hills are caused by the seepage from rain water which soaks into the hills, dissolves the easily soluble alkali salts, and then in part slowly seeps out and is evaporated, leaving the alkali on or near the surface.

The alkali of the Walla Walla Valley is nearly all carbonate and bicarbonate of sodium. This is what is known as "black alkali," the most harmful salt found in the soil. One-tenth of 1 per cent of this alkali is sufficient to kill any of the useful plants grown in this region. While the total salts in the surface 6 feet rarely exceeds 0.20 per cent, there is quite an area in the western part of the district, along the Walla Walla River, that for the surface 3 feet contains more than 0.20 per cent of black alkali alone. The less harmful salts that are usually found in connection with the black alkali are here almost wholly absent.

Accompanying this report is a black-alkali map (Pl. XLII). This map shows the percentage of sodium carbonate in the surface 3 feet, this depth being selected because it is in the surface 3 feet that most of the alkali is found. In a few instances quite high percentages were found below the third foot, but these cases were rare. It is the usual custom to construct a total-salts map which, when the total salts compose 0.20 or more per cent of the surface 6 feet, shows the location and extent of such areas, but, since in this region the alkali is nearly all black and contained in the soil near the surface, this total-salts map was not constructed.

The black-alkali map shows four grades of soil—that containing less than 0.05 per cent black alkali, from 0.05 to 0.10, from 0.10 to 0.20, and that which contains more than 0.20 per cent. The soil which contains less than 0.05 per cent includes all the hill land and the greater part of the small valleys. Only a small part of the area sur-

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veyed contains enough alkali to be impaired for agricultural use. Five one-hundredths per cent in the soil from which the plants feed is enough to materially injure susceptible crops, like wheat or many of the vegetables. Barley will do fairly well on such land, and alfalfa if once well established will grow, though it will not thrive. Pears and apples are affected, but will live. As this amount is increased, however, the list of plants that may be grown rapidly diminishes until, when the concentration reaches 0.10 per cent, none of the crops of the valley will grow. All land which contains from 0.05 to 0.10 per cent requires careful cropping to produce anything at all, and must be cleansed of at least part of its alkali before it can be profitably farmed. All land containing more than 0.10 per cent must be reclaimed before crops can be grown.

RECLAMATION OF ALKALI SOILS.

There is no alkali land in the area mapped that can not be economically reclaimed. It is all situated in the small valleys along the streams, and when under cultivation and free from alkali is the most valuable soil in the Walla Walla country. The soils are all of such an open and porous nature that alkali may be readily washed from them, and the numerous small streams that intersect the area are usually far enough below the level of the valleys to afford good outlets for drains. These same streams afford ample and excellent water for irrigating all the land that is contained in the valleys. The present condition of the alkali areas is due either to neglect or to improper methods of cultivation. The most efficient way in which the land can be reclaimed is to remove the alkali in the way that it was accumulated—that is, through the action of water. If the land were continuously cultivated, or a mulch maintained in some other way, as by the application of straw or manure, the rainfall would in the course of a few years reclaim the areas that are now only partially injured. But since water for irrigation can be obtained so readily and so cheaply the rainfall should be augmented by irrigation.

In preparing the land for reclamation the greatest care should be exercised in getting it in such a condition that when water is applied all parts of the land will be covered. If high spots are left, the effect will be to concentrate the alkali in such spots. After the land is perfectly leveled it should be heavily flooded as often as possible, and if after this treatment the soil is still too strongly impregnated with the noxious salts to allow the cultivation of some crop, then as soon as dry enough the soil should be stirred to prevent evaporation and a return of the alkali to the surface. If this heavy flooding is done in the fall or winter, when the ground is not frozen, it will be more effective than if done in summer, for the evaporation is much less. As soon as enough alkali is washed out of the soil a crop should be seeded. Barley is one of the best crops to use in the reclamation, for it not only

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withstands relatively high percentages of alkali, but also effectively shades the ground and prevents evaporation. When a crop or two of barley has been grown, a stand of alfalfa may be obtained, after which, with fair treatment, not too close pasturing, and an occasional flooding, no difficulty should be experienced. If the ground water in any part comes to within less than 4 feet of the surface, deep ditches should be cut for drains, or tiles put in to carry off the surplus water.

This reclamation, even when tiles are necessary, can be accomplished very cheaply. In no case will expensive outlets have to be dug for the drains. Twenty-five dollars per acre should be ample to cover the expense even for the worst lands, which now are practically worthless. These lands when reclaimed are worth from \$80 to \$100 per acre.

AGRICULTURAL METHODS.

Contrary to Eastern and Middle Western practices, no rotation of crops is practiced in the Walla Walla area. Wheat and barley are grown continuously and almost exclusively, the only other crops being vegetables, fruit, and alfalfa grown along the streams. Of the staple cereals wheat has by far the larger acreage. Only enough barley is grown for home consumption. At first the same land was sown year after year to wheat, but this continual drain on its fertility, with no change or rest, soon began to have its effect in lessened yields. No crop has yet been introduced to rotate with the wheat, so that the common practice is to "rest" the land by summer fallowing it at least one year in three. The majority of farmers summer fallow alternate years, so that if a man has a 320-acre farm he will each year harvest 160 acres of grain.

Plowing for grain is done any time after the first heavy rains in the fall. This is done by plowing round and round the field with six or eight horse gang plows, the finishing of the "land" being at the center of the field. In the very hilly parts each hill is plowed around in this way until the field is finished. After being plowed the land may be harrowed, but it is usually left rough until late spring, when the weeds have begun to grow, when it is either harrowed, disked, or cultivated in some other manner to kill the weeds. An instrument now very much used for this purpose is what is called a "slicker." It consists of three parallel 5-foot sections of 2 by 6 scantling fastened together, like a "marker," with horizontal scantling 2 by 4 inches in dimension and 10 feet long. The front ends of the three parallel pieces are rounded to make them drag easily through the soil. Fastened to the lower rear end of these runners is a broad knife which extends the length of the "slicker." This knife passes a little beneath the surface and cuts off the weeds. Four horses are required to draw the implement, the driver riding upon it. Where the weeds are small this affords an excellent way of killing them, for the reason that it does

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not expose any great amount of moist earth on the surface. Another machine has been devised which in foul land bids fair to be a great boon to the farmer. This is a double disk working upon the same principle as the ordinary farm disk, but so arranged that one row of disks follows another, cutting the small spaces between the disks and throwing the soil in the opposite direction from that of the first disk. In both of these methods of cultivation the main object is to kill the weeds, and the machine which does this most effectively and with the least amount of labor is the one most popular with the farmer. The number of cultivations summer-fallow land may receive depends upon the growth of weeds. As often as the weeds grow up the land is cultivated, but this is rarely more than three times during a season.

The practice in growing winter wheat is to seed in the fall as soon as the first heavy rains have fallen. This gives the wheat a chance to make a vigorous growth before winter sets in and to be ready to withstand the cold. Seed is still principally sown broadcast and then harrowed in. For this a very large harrow, consisting of many diamond-shaped sections, is used. Six or 8 or even 10 horses are employed, driven by a man on horseback. A few have begun to use the wheat drills in common use in the East and Middle West. They are considered a marked improvement over the old broadcast system. After the grain is sown no further care is necessary until harvest time.

The greater part of the harvesting is yet done with headers, the wheat being stacked pending the thrashing, which is usually done by perambulating thrashing machines. Harvesting begins about the 1st of July and soon after the thrashers begin their work and quickly convert the heaps of heads into straw and sacks of grain.

Quite a number of farmers are now using the combined harvesters, which cut, thrash, and sack the grain all at the same time. These machines so far seem to be a success and the present season (1902) several new ones began operations.

The effect of summer fallowing upon the crop has long been experimentally determined by the farmers of the Walla Walla Valley. The bare, exposed fields are kept continually warm by the sun, while the surface cultivation acts as a mulch to prevent the escape of moisture by evaporation. This prevention of the escape of moisture is very noticeable. Fields were examined late in July at harvest time that had been summer fallowed and were found to contain below the thin covering of mulch sufficient moisture for plant growth, while neighboring fields of wheat were very dry to a depth of several feet. Thus in regions of light rainfall much of the benefit of summer fallow is due to the combining of the rainfall of two years for the growing of one crop. In addition to the increased activity of the micro-organisms to produce available nitrogen, the general condition of the soil is

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benefited by this complete exposure to the elements. General weathering is accelerated, breaking down the soil particles and setting free more rapidly than under ordinary conditions all the elements necessary for plant growth, so that while the old crop left the soil exhausted of moisture and impoverished in plant food, this year of rest has not really been one of rest at all, but a year of constant activity, making ready for the nourishment of the new crop.

The fruits grown in this area consist principally of prunes, apples, pears, and cherries, while a few other deciduous fruits are less extensively grown. Experience has shown that these fruits may be grown back in the hill lands without irrigation, but very few orchards are as yet planted outside the level, irrigated lands of the valleys. Most of the orchards are irrigated in furrows, the space between the trees being constantly cultivated and usually planted to some minor crop. The apple, pear, and prune require a great deal of labor and expense in spraying, the apple and pear being subject to attack by the codling moth and also together with the prune to damage by the San Jose scale. Cherries thrive and are less affected by pests.

The common practice is to plant truck or berries in the spaces between the trees in the orchards. These intermediary crops are irrigated from small furrows between the rows, the water being diverted from the streams in small ditches. No irrigation systems of any great extent are in operation.

All kinds of truck are grown. Potatoes, onions, cabbage, and asparagus, however, are the principal products. For early spring cabbage the plants are set out in the fall in rows 3 feet apart, with the plants 2 feet apart in the row. These plants withstand the freezes of winter. Potatoes and onions are also planted in the fall for early spring crops. Potatoes are planted in rows 3 feet apart and often reach maturity without irrigation. Onions are drilled in rows 12 inches apart and irrigated by making small furrows in alternate spaces between the rows. All the work after seeding onions must be done by hand, which makes their cultivation expensive. One man can attend to only about 1½ acres.

Strawberries and raspberries are irrigated and cultivated much the same as truck crops. The strawberries are planted in rows 3 feet apart and 18 inches apart in the row. Small ridges are thrown up and the plants set out on top of these ridges. Raspberries are set out 6 feet apart both ways.

AGRICULTURAL CONDITIONS.

The Walla Walla Valley bears a marked air of prosperity. A failure in crops has never been known, and as new markets have been opened and transportation facilities increased the condition of the agricultural and dependent industries has steadily improved.

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The farms are nearly all owned by the operators. The grain farms range in size from 160 acres to several hundred acres. In the vegetable and fruit growing district near Walla Walla the farms are divided into small tracts of from 10 to 20 acres, which are mainly rented to Chinese or Italian gardeners.

Grain farming does not require the attention of the farmer the entire year. There are two busy seasons, seedtime and harvest. Except for the necessary cultivation to kill weeds on the summer fallow no labor is necessary the remainder of the year. It is only during these busy seasons that the farmer needs to employ labor. Both seasons are short, so that responsible labor can not afford to come to the region for these short periods. The consequence is that a nondescript body of laborers come and go at these seasons. This labor is very unsatisfactory, but until the crops grown are such as to furnish labor for reliable men during the entire year little or no improvement in labor conditions can be expected.

Wheat is the principal crop. Hundreds of tons are produced each year, the greater part of which is exported either as grain or flour. Several varieties of wheat are grown, chief among which in order of importance are the blue stem, club, Salt Lake club, and red chaff. Blue stem is the variety most generally grown, since it is from this wheat that the best flour is made.

Enough barley is grown to supply home demands for feed and the local breweries. In the small valleys near Walla Walla excellent vegetables and berries are grown. These are handled by produce shippers, who buy the produce outright from the growers and ship it principally to points in the Dakotas, Montana, and British Columbia. As already mentioned, most of this truck is grown by Chinese and Italian gardeners, who rent the land in small tracts from the owners. This truck land is relatively very valuable, being worth from $100 to $150 per acre. Farther from town the valley lands are seeded almost exclusively to alfalfa. Three crops of hay are usually cut each year, and the fields also afford some pasture. The hay is principally sold to sheep and cattle men, who bring their stock down from the mountains to winter. The average price of alfalfa hay is about $4 per ton. A part of the wheat and barley is also cut for hay, and this usually sells for a little more than the alfalfa. In the western part of the area dairying has gained quite a foothold. Nearly all the farmers along the river have a few cows, the milk from which they sell to the creamery. Throughout the area the farmhouses are built wherever it is possible along the small streams, so as to be near water. South of Dry Creek, if no part of a stream is included on the farm, water may be had by digging shallow wells, but north of this creek no one has as yet been successful in finding water. A solid sheet of lava, which is very hard to drill and has never been penetrated, is encountered at

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from 30 to 50 feet. Throughout this part of the area the procuring of water for stock upon the farms is a great problem. Cisterns are built and filled in winter, but these are usually empty before harvest time, and water has to be hauled from either the Touchet River or Dry Creek. The expense of hauling water through harvest is very great, as the roads are very hilly and only small loads can be hauled.

Walla Walla now has two railroads connecting the valley with the East and with the Pacific coast, so that there is no lack of transportation facilities. A narrow-gauge road also extends northeast from Walla Walla through the area mapped, tapping the rich wheat belt in that direction. Before these railroads were built and when there was only a narrow-gauge road to Wallula, wheat, being nonperishable, could be shipped, but the growing of vegetables and fruits was limited to home demand, and these industries owe their present importance entirely to the fast-freight system of the railroads. Although each field is small, this gardening, taken as a whole, adds not a little to the revenue of the valley. An average of about 2 carloads of garden produce is shipped daily, besides the amount consumed in Walla Walla.

The hauling of the wheat from the fields to the warehouses is the greatest item of expense in transportation. The country roads are, as a rule, very poor; only those roads that follow along the streams are in a fair condition. The others, which are made to follow section lines or other arbitrary divisions, go up hill and down, irrespective of contours. Some of the hills are very difficult to climb, and this makes the hauling of ordinary loads impossible, greatly increasing what would normally be the cost of hauling. The bettering of the roads by leveling would be an endless task and one involving great expense, and it is doubtful if much improvement will be made in this direction for many years to come.

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SOIL SURVEY OF THE LOWER ARKANSAS VALLEY, COLORADO.

By **MACY H. LAPHAM and PARTY.**

LOCATION AND BOUNDARIES OF THE AREA.

The Lower Arkansas Valley area lies in southeastern Colorado. It embraces large areas of land in Otero, Bent, and Prowers counties and is traversed from west to east by the Arkansas River. This stream, one of the few which rise in the mountains of the Rocky Mountain system

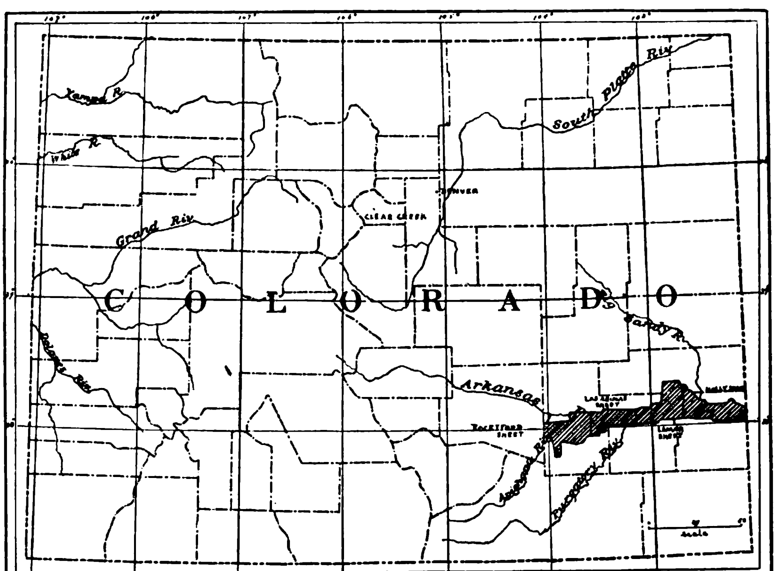

FIG. 23.—Sketch map showing area surveyed in Colorado.

and, flowing eastward, break through the Great Plains, is of great importance to this section of the State as a source of water supply for irrigation purposes.

This area is one of the most important agricultural sections of the State and is watered by some of the most extensive storage reservoir and canal systems of the arid West. Its soils are famed for their fertility, and the Arkansas Valley is known for its stock-feeding industries and for its production of alfalfa, sugar beets, melons, fruits, honey, vegetables, and other staple articles of food.

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The area surveyed has an extent of 945 square miles. For its western boundary the township line 6 miles west of the city of Rockyford, in Otero County, was chosen. From this point the area extends eastward about 100 miles to the Colorado-Kansas State line. Its breadth from north to south varies from 6 to 20 miles, embracing all of the land of the valley bottoms and extending out on the plains to the limits of irrigation.

For convenience the map of the area is published in four sheets, named, from west to east, the Rockyford, Las Animas, Lamar, and Holly sheets.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The early history of this region opens with the exploration of the "Great American Desert," a vast area of land extending westward across the continent from the borders of the semiarid belt. Of indefinite boundaries, this unknown tract has gradually shrunk in extent under the aggressive campaign of the pioneer plainsman until the name by which it was once known has become almost obsolete.

In the early thirties a few venturesome trappers and traders found trading with the friendly Indian tribes for beaver and other pelts profitable and erected temporary headquarters or forts in which they could defend themselves from thieving or murderous bands of savages.

With the further exploration and settlement of the West came the prairie schooner of the pioneer and the armed wagon train of the freighter. Each wagon was generally hauled by from 10 to 12 mules, horses, or oxen, and at night patrols were established to provide against a possible attack by Indians. With immigration from the Eastern and Middle States and the establishment of stage lines bands of outlaws also infested the region.

In 1847 the famous Santa Fe stage line was established, which followed the Santa Fe trail from Independence, Mo., to Santa Fe, N. Mex. Following the discovery of gold on the Pacific coast, this travel was greatly augmented by the freight and prospectors' wagon trains and by the establishment of military posts throughout the West. Many of the towns in the area surveyed were at one time important stations on this stage route.

There are records of the growing of isolated patches of grain and vegetables by the aid of irrigation in the Arkansas Valley as far back as 1854. Grazing was for many years, however, the only important form of agricultural industry practiced, some of the most valuable lands being held in large tracts as grants.

With the encroachment of the settlers and the disappearance of the buffalo before the attacks of the pelt hunters the plains Indians became jealous and more troublesome. At last their depredations assumed such proportions that Colonel Chivington, in command of a Colorado regi-

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ment, was sent to punish those who had treacherously taken the warpath while pretending to be upon friendly terms with the whites. At Big Sandy Creek, in Kiowa County, some 25 miles north of Lamar, he met and defeated the allied bands, after which there was no more trouble from Indians upon the plains of Colorado.

Following the construction of the Santa Fe Railway, which displaced the stage coach, the settlement of the region was more rapid, and practical farming began to receive some attention. With the settlement of the Middle West immigration had gradually pushed the domains of the practice of dry farming westward. There came a time, however, when its borders could not be further extended with safety. The gently undulating or level lands of the Great Plains, by reason of their easily tillable condition and fertile soil, had always proven very alluring to the home seeker. With an occasional season or two of abundant rainfall the tide of immigration rapidly extended into the subhumid belt. The recurrence of seasons of drought, however, always rapidly depopulated these sections, leaving only deserted buildings, abandoned towns, and an occasional broken-down fence as evidences of their former occupation.

Such has been the case in the eastern portion of the Arkansas Valley in Colorado, but to a much less extent than in the more easterly States. Throughout the greater portion of the area, however, the aid of irrigation has always been recognized as necessary to the successful practice of agriculture.

About 1872 the construction of the Rockyford Canal, the first large irrigation system, was begun. Those engaged in grazing soon learned the value of alfalfa as supplementary to the range in the fattening of cattle, sheep, and swine. This has brought about the evolution of the range steer from the wild, long-horned, angular cattle fitted for market entirely upon the range, to the more stocky modern breeds of the alfalfa districts. Alfalfa grows luxuriantly and also finds a ready sale as hay, being shipped in large quantities.

The construction of the Fort Lyon Canal, the largest in the area, was begun about 1884 and was supplemented and followed by several other systems. When the practice of irrigation had been established, the introduction of grains, fruits, and vegetables followed, although alfalfa continued to be and is yet the staple crop.

Several years ago it was noticed that melons, planted for home use, acquired an especially fine flavor. This led first to their production for local markets and gradually to the introduction of the industry upon a large scale to supply the markets of the East.

Experiments also proved the success of the growing of sugar beets upon the soils of the valley. Through the efforts of the pioneer settlers some of the land was divided and settled in small tracts. These people then, through cooperation with business men, succeeded

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in interesting capital, and the American Sugar Beet Factory was erected at Rockyford. With this came rapid development of a more intensive system of agriculture, the establishment of truck farming, and the growing of tomatoes and beans for canning purposes. Fruit growing also has recently become a flourishing and important industry.

CLIMATE.

The climate of this district is essentially arid. This condition is a direct result of topographic and atmospheric features and is characteristic of nearly all the western half of the continent, excepting only the mountain regions. The winds, descending to the plains on the eastern side of the mountains, have already been robbed of their moisture. As they reach the plains they are warmed and their capacity for moisture is increased. This condition is generally accompanied by cloudless skies, low relative humidity, high temperatures, and frequently by vigorous wind movement, all of which serve to increase evaporation from the fields and rapidly dwindling streams. These conditions of an abundance of sunshine, dry and pure air, and cool nights are, however, extremely healthful, and the climate of the Arkansas Valley is especially beneficial in cases of pulmonary complaints.

The annual rainfall of this region shows considerable variation in amount from year to year. Series of seasons of a more abundant precipitation sometimes follow those of drought. This has at times given rise to the theory that a permanent climatic change in favor of greater rainfall was taking place over the Great Plains, caused by a more complete settlement and cultivation of the prairie lands. However, by a study of observations covering long periods of time this theory is readily disproved.

During the winter and early spring westerly cyclonic storms occasionally occur. Such disturbances are generally preceded and followed by several hours or days of cloudiness and high winds, with precipitation taking place usually as a gentle rain, lasting two or three days. Rains so falling soak into the soil and do the greatest possible amount of good. In the summer months long-continued rains rarely occur. Local showers, often accompanied by wind and dust storms, thunder, lightning, and hail, are, however, not infrequent. They often assume the proportions of cloudbursts, especially in the vicinity of the foothills and mountains. The water thus falling runs off rapidly, frequently sweeping down the streams and arroyos and causing considerable destruction of property, and is of but little aid in supplying the soil with needed moisture. While not always of a violent nature, the summer showers are so local in character as to be productive of but little good, covering very small areas and often recurring at a given place only at long intervals.

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The winters are short and generally mild, sometimes interfering but little with farm labor. Occasionally, however, the cold becomes severe. Such periods are of short duration and are soon followed by mild weather.

During the summer the days are frequently hot, the temperature for the warmest periods ranging from 90° to 105° F. With favorable moisture conditions and the usual prevalence of sunshine this insures rapid plant growth. The nights are generally cool and pleasant, and periods of cool days frequently occur.

The following tables, taken from records of Weather Bureau stations at Rockyford, Las Animas, and Lamar, show the normal monthly and annual precipitation and dates of killing frosts:

Normal monthly and annual temperature and precipitation.

Month.	Rockyford.		Las Animas.		Lamar.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° *F.*	*Inches.*	° *F.*	*Inches.*	° *F.*	*Inches.*
January	27.9	0.46	35.6	0.24	30.1	0.27
February	30.2	.40	31.6	.32	31.6	.42
March	39.5	.58	40.6	.46	41.5	1.09
April	51.9	1.34	51.4	1.23	53.3	1.83
May	60.8	2.06	62.0	1.82	63.0	2.05
June	70.5	1.31	72.6	1.31	73.4	2.18
July	74.3	3.50	77.2	1.98	77.7	2.97
August	73.9	1.44	74.9	1.77	76.6	1.52
September	65.4	.74	65.6	.95	68.6	1.24
October	52.8	.87	52.8	.63	54.5	.96
November	39.0	.42	37.6	.23	40.9	.41
December	31.1	.59	29.3	.40	32.6	.68
Year	51.4	13.71	52.6	11.34	53.7	15.62

Dates of killing frosts.

Year.	Rockyford.		Las Animas.		Lamar.	
	Last in spring.	First in fall.	Last in spring.	First in fall.	Last in spring.	First in fall.
1893	May 8	Oct. 2	May 15	Oct. 2	Apr. 29	Oct. 2
1894	May 1	Sept. 24	May 2	Oct. 4	....	....
1895	May 11	Sept. 22	May 19	Sept. 22	....	Sept. 22
1896	Apr. 29	Oct. 11	Sept. 29	Oct. 11	Apr. 30	Oct. 11
1897	....	Oct. 29	Apr. 22	Oct. 12	Apr. 29	Oct. 11
1898	Apr. 28	Sept. 13	May 11	Sept. 6	May 6	Sept. 7
1899	May 4	Oct. 5	May 1	Oct. 13	May 1	Oct. 5
1900	Apr. 12	Sept. 29	Apr. 13	Oct. 7	Apr. 12	Sept. 29

This region is marked by a generally low relative humidity. The contrast between the sensible and instrumental temperatures is striking. Owing to the dry atmosphere the cold waves of the winter lose their severity, and the intense sunshine and heat of summer lack the

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oppressiveness so often experienced in the Eastern States. Sunstrokes and heat prostrations are almost unknown, and in the shade it is comfortable even at a temperature of 105°.

The almost entire absence of cloudiness during the winter and the only occasionally cloudy weather during the summer form the most notable and distinctive climatic features of southern and eastern Colorado. The abundance of sunshine is of great value as affecting the health of the inhabitants and in assuring the rapid and continuous growth of crops.

Fogs are of very rare occurrence in the Arkansas Valley. Generally brisk winds are, however, a distinctive climatic feature of this region. The topography and vegetation of the plains offer but little resistance to a free wind movement, and during the spring months the winds are brisk and are sometimes violent and accompanied by dust storms. Any considerable amount of damage is, however, rarely done. With the approach of the summer months the winds moderate, although they usually blow more or less throughout this season of the year. For short periods during the warmest weather the winds sometimes become intensely hot and dry during their passage over the prairies.

PHYSIOGRAPHY AND GEOLOGY.

The area surveyed falls into two distinct physiographic divisions—the Arkansas Valley proper and the uplands.

The uplands consist of a succession of smooth, even, gently undulating prairies characteristic of the Great Plains. In places erosion has resulted in the degradation and removal of portions of the original material, giving rise to prominent bluff and terrace lines, often cleft by arroyos having vertical sides and traversed by streams of a more or less intermittent flow. The vegetation of these uplands consists of the short and scanty but highly nutritious buffalo grass, bunch grasses, sage bush, "soap weed," and a great variety of small flowering annuals.

The soils are generally deep, but outcrops of the underlying rocks are abundant along the bluffs and terraces.

The general slope of the plains is from the northwest to the southeast, the elevation ranging from almost 3,400 feet at the eastern boundary of the area to about 4,400 feet at the highest point near the western boundary.

Farther back from the valleys the slopes become less accentuated and drainage is less efficient. Here the rainfall is largely absorbed by the soil or accumulates in broad, shallow depressions, forming lakes of an intermittent character, often connected into groups or chains. Such natural depressions, if favorably situated, have become of great importance to this area as possible sites for water-storage reservoirs.

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In desert regions a large amount of material is torn loose and swept away by the mountain streams, augmented by cloudbursts and storms of great intensity and short duration, and carried to the more gentle slopes below. Owing to decrease of velocity or to the absorption of the water by the porous and thirsty soil, the material is here spread outward and deposited in fanlike sheets bordering the mountain ranges. With changes in level due to uplifts and depressions of the earth's crust or to the cutting down or building up of the stream channels, the stream beds are continually shifting and the débris apron—a broad, extensive sheet of stream-borne material formed by the coalescing of many smaller fans—is the result. These shifting streams give rise to what is known as the phenomenon of laced drainage, resulting in a mass of interlaced and interbedded deposits of material of varying degrees of fineness, ranging from coarse gravel and bowlders to silt and clay. In this manner at least the greater part of the Great Plains has been built up, the mountain foot slopes in this case being very extensive and complex.

Occupying the subhumid belt of the Great Plains and constituting a distinct physiographic feature are the high plains, or that portion of the original foot slope still unscored by erosion. The surface is here nearly a dead level and the soil is closely carpeted by a fine turf, the bunch grasses found farther west having disappeared. These plains have practically no drainage, the precipitation being absorbed by the soil. The depth of the débris apron is here greatest, being upward of 500 feet. Only a limited proportion of the uplands of the eastern part of the area surveyed fall under this subdivision, the great body of the high plains lying east of the Colorado-Kansas State line.

The Arkansas Valley proper forms a trough from 2 to 5 miles wide and in the area surveyed from 100 to 300 feet deep, carved out of the Great Plains by the Arkansas River during recent geologic time.

Prominent bluff lines mark the borders of the valley through much of the area, as in the vicinity of Lajunta. At other points more gradual slopes prevail, with minor terraces of gravels, sands, and heavy silt and clay deposits, each terrace being the remnant of an ancient river flood plain. The waters of the streams of the area carry much fine sediment and, in periods of flood, material of a coarser nature. This has resulted in the deposition of much material upon the eroded surface of the valley trough.

From Canyon City to the Kansas line the Arkansas River has a total fall of 1,975 feet, or an average of 9 feet per mile. From Lajunta to the Kansas line the average fall is 7.3 feet per mile. This, with the generally smooth and slightly sloping condition of the valley terraces and of much of the uplands, offers favorable conditions for irrigation.

The important tributaries of the Arkansas rising in the mountains are Fountain Creek and St. Charles Huerfano, Apishapa, and Purga-

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toire rivers, the latter discharging its waters into the trunk stream in the vicinity of Las Animas, being the only one entering the Arkansas within the limits of the area surveyed. Many other streams, as the Horse, Adobe, Timpas, and Big Sandy creeks, receiving their water supply from the springs and uncertain storms of the plains, form less important tributaries. Many of these smaller streams flow through narrow valleys or draws, into which the irrigating systems of the main valley are extended.

Changes in level, in combination with the fluctuation in river flow, have produced many alternating periods of erosion and deposition of material in the history of the valley.

The larger streams are bordered with a heavy growth of cottonwood, the trees sometimes attaining a large size. The lighter soils are covered with the vegetation of the upland sands and sandy loams, while the grasses of the heavier soils and occasional patches of "greasewood" are the characteristic vegetation of the heavier bottom lands.

The physiography of the valleys, as well as that of the uplands, has in many respects been modified by wind action.

The rock series of the district consist of alternating beds of sandstone, limestone, and shales of marine origin and of the Cretaceous period. These beds vary greatly in thickness and are generally nearly horizontal, inclining slightly to the eastward at about the slope of the plains. In many places the general structure and occurrence of the rocks have been greatly modified and complicated by local faulting and bending of the strata.

The rocks of the softer series erode easily, and under the agencies of frost, wind, and atmospheric waters rapidly crumble into the soils of the area, the silty and fine sandy loams predominating. Soluble mineral salts are readily leached from these rock outcrops and added to the soils below.

Underlying the Cretaceous rocks are found those of the Jura-Trias, consisting of sandstone, limestone, conglomerate, shale, and gypsum. They are usually of brilliant reddish colors and close texture.

The rock series of the Cretaceous system found in this area are classed under three well-recognized groups.

The Dakota group is the lowest of the series, consisting chiefly of light gray or buff-colored sandstone, sometimes dark brown or chocolate on weathered surfaces, with occasional brilliant or orange colors in the lower beds. Beds of gray arenaceous shales, containing particles of carbonized vegetable tissue, alternate with the sandstone layers. The Dakota sandstones vary much in texture, the lower beds being of a more porous nature. This rock furnishes an abundance of excellent building stone and is also important as the source of artesian water throughout the area. It outcrops a few miles east of Las Animas, forming prominent bluffs on each side of the river. The thickness of this group varies, but averages from 200 to 250 feet.

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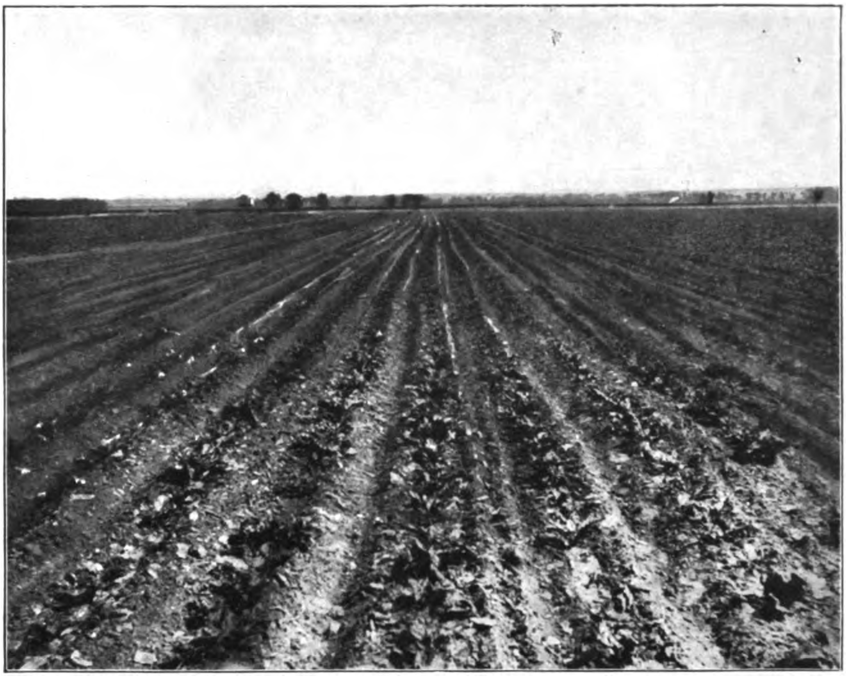

FIG. 1.—A FIELD OF SUGAR BEETS, ONE OF THE IMPORTANT CROPS OF THE ARKANSAS VALLEY.

FIG. 2.—ALFALFA STACKS AFTER THE SECOND CUTTING OF THE CROP, LOWER ARKANSAS VALLEY.

This is one of the industries which has been remarkably successful in the Arkansas Valley.

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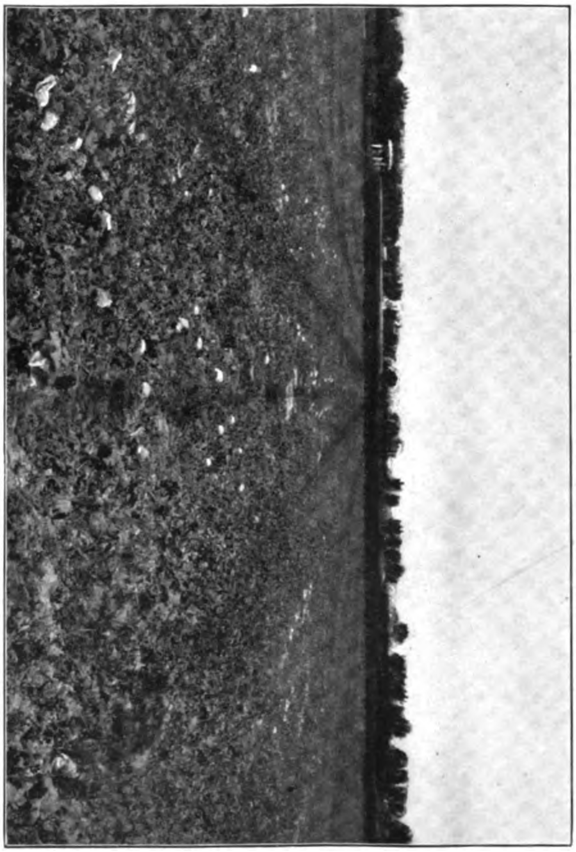

A FIELD OF CANTALOUPES, THE GROWING OF WHICH HAS BEEN REMARKABLY SUCCESSFUL IN THE ARKANSAS VALLEY.

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The Benton group rests upon the upper members of the Dakota. In general character it is a highly laminated gray shale, streaked with black bands. Calcareous concretions, weathering to brilliant orange in color, and fossil oysters and other bivalves frequently occur. It is divided near the middle by strata of limestone only a few inches in thickness, weathering into vertical parallel chips and separated from each other by beds of shale. The upper members of this group sometimes assume the characteristics of a sandstone or a purplish limestone containing fossil shells. The whole system is quite regular and from 400 to 450 feet thick. It outcrops and forms prominent bluffs from a point near Lajunta to Las Animas.

The Niobrara group lies above the Benton and consists of two distinct formations—the Timpas, or lower formation, and the Apishapa.

The Timpas formation is about 175 feet thick and consists of a series of limestone and calcareous shales. The limestone beds have a thickness of from a few inches to 3 or 4 feet, are white or slightly yellowish in color, of a compact texture, and weather into sharp angular flakes or chips. Fossil oysters and other bivalves are abundant. This formation borders the valley eastward from Timpas Creek until the rocks drop off into those of the Benton group. It is exposed in prominent bluffs on each side of the river at Lajunta.

The Apishapa formation rests upon the Timpas, and consists of laminated dark gray shales weathering to light yellow. Small veins and flakes of gypsum are abundant throughout this formation. Large rounded bowlders, like calcareous concretions, containing large checks filled with calcite and barite crystals, frequently occur. This formation crops out throughout the area eastward from Timpas Creek, and has a maximum thickness of about 500 feet.

The Tertiary deposits are of a more recent date, overlying the Cretaceous rocks and making up the unconsolidated material of the débris apron of the Great Plains. In texture the material grades from clays and fine silts to the coarse, loose upland sands and coarse gravels, and is from 50 to 200 feet in thickness. The sands are chiefly of granitic origin, consisting of quartz and felspathic fragments, and the particles are quite well rounded and abraded. Heavy deposits of coarse, well-rounded gravel are numerous, being most abundant along eroded bluff and terrace lines. This material is derived from the harder rocks of the Rocky Mountains, consisting largely of the rocks of the granite series. Fragments of volcanic origin also occasionally appear. At certain places, particularly where the Tertiary rests upon the Cretaceous, the gravels and sands are often cemented by calcareous material into a hardpan or conglomerate several inches in thickness and known as the "mortar beds." These are often cross bedded and are thought to mark former levels of the water table, the cementing material being precipitated from solution by atmospheric agencies.

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The terrace sands and gravels of the valley are quite similar in character to those of the uplands, but less extensive. The recent deposits consist largely of fine sand and silts, vast quantities of which are carried by the Arkansas River in times of flood.

SOILS.

The soils of the Lower Arkansas Valley area, through their relation to geologic and physiographic features, fall into two natural divisions, the soils of the plains and the soils of the valley. In places, however, the soils of the two divisions are separable only upon lines of arbitrary classification.

In general the soils of this area are marked by complexity of structure and mode of occurrence, by the prevalence of small areas, a rapid and widespread variation from type to type, and an apparent disregard of physiographic influences in the arrangement and position of types. The deposits of sands, gravels, and clays are intricately mixed, forming very confusing conditions in soil study. This complex arrangement exists both in the soils of the upland plains and in those of the valley.

With the exception of the coarser and lighter deposits, the soils of the Arkansas Valley area are well provided with plant food, both mineral and organic. The occurrence of lime in the soils is marked and the valuable mineral nitrates are abundant. The moisture-retaining properties of the lands of this area also greatly enhance their value for agricultural purposes.

Areas of different soils.

Soil.	Rocky-ford sheet.	Las Animas sheet.	Lamar sheet.	Holly sheet.	Total area.	Proportional extent.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Per cent.*
Fresno fine sandy loam	56,384	13,632	94,720	71,552	236,288	39.1
Maricopa sandy loam	63,424	39,104	15,872	37,696	156,096	25.8
Fresno sand	14,592	12,800	13,056	55,232	95,680	15.8
Santiago silt loam	6,784	8,640	12,608	9,728	37,760	6.2
Maricopa sandy adobe	13,888	13,056	9,280	1,024	37,248	6.2
Maricopa sand	11,264	896	832	1,216	14,208	2.3
Riverwash	2,432	3,264	3,008	4,096	12,800	2.1
Fresno fine sand	1,280	960	1,344	2,368	5,952	1.0
San Joaquin black adobe	1,216	2,240	640	....	4,096	.7
Dunesand	....	2,368	384	576	3,328	.6
Maricopa clay loam	320	....	512	....	832	.1
Swamp	256	....	384	....	640	.1
Total	171,840	96,960	152,640	183,488	604,928	....

FRESNO SAND.

The Fresno sand is typically a coarse, loose, incoherent sand, 6 feet or more in depth. It is underlain at varying depths by the heavier loams, sandy adobe, or shale or sandstone rocks. In color it is white,

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or of a yellowish or slightly reddish tint, the latter due to the prevalence of feldspathic fragments, which, with quartz, form the chief mineral constituents. It usually breaks down into a loose mulch upon being turned up by the plow, containing but little clay and rarely forming clods. Occasionally, however, it assumes a sticky nature, although containing but little silt or clay, and bakes upon being puddled and exposed to the sun.

The following table gives mechanical analyses of soil and subsoil of this type:

Mechanical analyses of Fresno sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7944	Sec. 32, T. 22 S., R. 56 W.	Coarse reddish sand, 0 to 12 inches.	0.50	0.64	14.30	25.90	37.66	13.80	2.28	5.50
7942	Sec. 21, T. 23 S., R. 55 W.	Coarse granitic sand, 0 to 72 inches.	.61	.14	7.70	18.52	34.66	21.92	7.82	9.32
7943	Sec. 3, T. 22 S., R. 56 W.	Coarse sand, 0 to 18 inches.	.81	1.90	9.14	12.76	27.92	23.62	13.14	11.92
7945	Subsoil of 7944....	Coarse reddish sand, 12 to 72 inches.	.12	.80	12.54	26.00	36.00	14.52	3.18	7.06

This soil varies somewhat in texture, physical condition, and physiographic position, a valley phase which is somewhat coarser in texture and frequently gravelly occurring upon the terraces of the bottoms.

The typical upland Fresno sand occurs generally in relatively large areas, often covering several square miles of uniform texture, and is the most easily recognized type of the area. In the valley the areas are usually small. The occurrence of gravel in this soil is seldom conspicuous except in the vicinity of eroded bluffs and outcrops of the Dakota sandstones eastward from the Purgatoire River, and in the valley phase.

The Fresno sand forms the greater proportion of the upland sand areas of the Great Plains of southeastern Colorado. It generally occurs upon the higher slopes and ridges or along the domelike elevations of the plains, sometimes dipping into the depressions. It usually grades rapidly into the Maricopa sand, Dunesand, Maricopa sandy loam, or the Fresno fine sandy loam. Outcrops of the underlying rocks seldom occur in areas of this soil.

The native vegetation consists of sage, "soap weed," and sunflowers, with many small flowering annuals and occasional patches of buffalo or other nutritious grasses.

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The open, porous nature of this soil allows of the rapid absorption and percolation of water and the establishment of excellent natural drainage conditions. In the larger areas there is but little run-off, nearly all the rainfall being absorbed.

The Fresno sand is made up of the more resistant particles of the rocks of the Rocky Mountains, deposited by the interlacing streams of the formative period of the Great Plains. The action of wind has since played an important part in distributing and modifying the texture and arrangement of the sands.

Small mica plates frequently occur in the soil, but the presence of this mineral is not conspicuous. No injurious quantities of alkali are found in the soil, except in depressions in the valley areas or where the seepage waters have come to the surface.

Considering its open, porous texture, it retains moisture well and contains a good supply of mineral and organic plant food. For heavy cropping, however, it is inferior to the heavier soils unless well supplied with moisture and with an abundance of organic and mineral fertilizers. But a small proportion of the upland Fresno sand is under cultivation, the most of it lying above the canal systems of the plains and much of it being public land and devoted to grazing. Native range grasses grow quickly upon this soil when once started and provided with the necessary moisture, furnishing good pasture. Much of the land, however, is of so loose a character as to be inferior to the heavier lands for grazing purposes, sage being in many places the only vegetation. This is the case particularly south of the Arkansas River. Upon cultivated portions alfalfa, grains, corn, melons, and fruit—consisting of peaches, apples, small stone fruits, and grapes—do well if well irrigated and supplied with plant food by stable manure or green manuring. (See Pl. XLV.) In the valley areas sugar beets are also grown, in addition to the foregoing crops, and fair yields are secured.

DUNESAND.

The Dunesand occurs upon the Las Animas, Lamar, and Holly sheets, occupying usually the higher elevations of the lands surveyed upon the plains of the south side and grading into Fresno sand.

The areas are very uniform in texture and general character. Gravel occurs only in insignificant amounts.

In texture, color, depth, mineral and chemical composition, and drainage features it is similar to the Fresno sand, being formed from the latter by the strong prevailing northwest winds, which have heaped the loose Fresno sand, not well protected by vegetation, into lines of shifting sand dunes from 6 to 20 feet high. The surfaces of the dunes are often barren and scored by wind ripples.

All of the areas of Dunesand lie above the irrigating canals and, owing to their uneven nature and loose structure, could not be irri-

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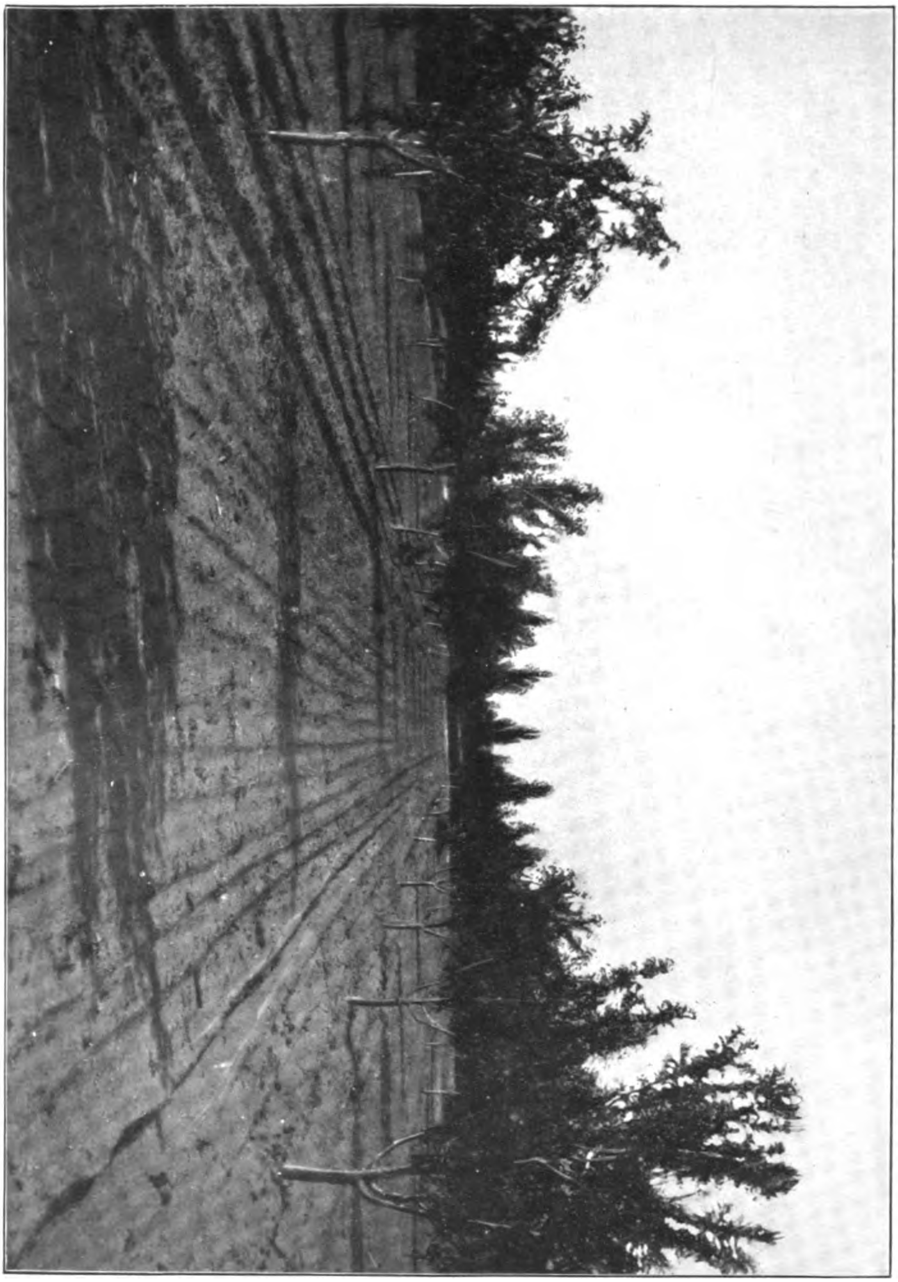

A YOUNG ORCHARD ON THE FRESNO SAND, LOWER ARKANSAS VALLEY.

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gated if a water supply were available. They are uninhabited and used only as range land. The vegetation, consisting chiefly of sage, is of but little value for grazing purposes.

MARICOPA SAND.

In texture, color, mineral and chemical composition, and physical properties the Maricopa sand is identical with the Fresno sand. It is, however, a much shallower deposit. In typical profile it is 3 feet in depth, underlain by a sandy loam, frequently grading to a sandy adobe, the materials in both cases being similar to those forming the Maricopa sandy loam and the Maricopa sandy adobe. It differs, then, from the Fresno sand in this heavier material occurring at an average depth of 3 feet, which in the Eastern States would not be a sufficient basis for a new type, but which in this Western area would have an effect upon the water supply in the soil, particularly under irrigation.

The Maricopa sand occupies the higher slopes and levels of the plains upon each side of the river, frequently bordering the deeper deposits of the Fresno sand. The largest areas of this type occur in the vicinity of the Holbrook reservoir and to the eastward. The areas are generally small, and there is usually but little variation in texture, although in certain local places, as in the Fresno sand, the soil has a peculiar sticky property. Small gravel areas frequently occur within the boundaries of this soil type, especially in the vicinity of terrace lines and along outcrops of the underlying rocks. With the exception of the Dakota sandstones, however, there are few rock outcrops in the Maricopa sand. This soil type grades into the Maricopa sandy loam and the Fresno sand, the native vegetation being similar to that on the latter.

As in the Fresno sand, the loose, open texture of the Maricopa sand results in excellent natural drainage and the ready absorption of the spring rains and local showers of the summer months. Owing to the heavier subsoil, it is superior to the Fresno sand in its power to retain moisture and when irrigated suffers less loss from seepage.

The origin and mode of formation of the Maricopa sand is the same as that of the Fresno sand, it being simply a shallower deposit of the same material. In its distribution it also owes much to wind movement, which has played an important part in forming the deposits from the neighboring Fresno sand.

Like the other upland sands of the plains this soil is free from alkali in injurious amounts.

The greater part of this soil type lies above the irrigating systems of the area and is devoted to grazing. Upon irrigated tracts, however, this soil is superior to the deeper sands for agricultural purposes. Alfalfa is the prevailing crop, yielding well under proper irrigation.

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With the aid of an occasional intelligent application of green or stable manure and a sufficient supply of water this soil should produce fair crops of alfalfa, grain—including corn and sorghum—and sugar beets. It is best adapted, however, to tomatoes, melons, and truck and to the growing of crops requiring a light, warm soil to insure an early and rapid growth. Fruit—consisting of peaches, apples, cherries, plums, grapes, and small fruits—would probably do well and become a profitable line with favorable markets. Frequent and intelligent cultivation is most important with lands of this texture in order to properly conserve the supply of moisture.

MARICOPA SANDY LOAM.

The Maricopa sandy loam, like the Fresno sand, occurs both upon the upland plains and in the valley bottoms.

In its typical upland phase it occurs as a coarse, slightly reddish or yellowish sandy loam. In depth the soil varies, but the average profile gives about 18 inches of sandy loam underlain by sandy adobe. In local areas the texture assumes a fine, silty character, tenacious when wet, and grading into the finer and heavier soils of the area. In other places the soil becomes much deeper and more open in texture, approaching the Fresno sand. Such phases frequently occur in the uplands, but more often upon the valley floor.

A peculiar phase of the Maricopa sandy loam occurs as a reddish, coarse, sandy loam, very compact, crumbling only upon considerable pressure, and checking upon puddling and exposure to the sun and air. This phase occurs in many local areas resembling the Maricopa sandy adobe, into which it often quickly grades.

This type covers a large proportion of the uplands upon each side of the valley. The most extensive areas, however, occur upon the plains of the north side of the western part of the area. The areas are usually large, although often much complicated and cut by narrow strips and small bodies of the adjacent soil types, particularly those of the upland sands and the Maricopa sandy adobe.

The occurrence of local gravel beds in soils of this type is very noticeable. Gravel often occurs in moderate amounts throughout the subsoils of the uplands. Along the eroded edges of the valley walls this gravel seems to have been washed out and concentrated into beds bordering the bluffs and terrace lines. These gravel beds where exposed at the surface are often very narrow, being only a few rods wide, but forming a very prominent physiographic feature. The rock fragments are generally well rounded and often coated with a thin incrustation of lime, especially in the vicinity of the "mortar beds" previously mentioned. These gravel-bordered terraces of the Maricopa sandy loam are of but little agricultural value, the gravel being present in such quantities as to interfere with cultivation of the lands

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and varying from the size of a pea to 4 or 6 inches in diameter. The position of these gravel-capped bluff lines is shown upon the soil maps. As the soils recede from the terraces the occurrence of the heavy gravel quickly becomes less marked or entirely disappears. A moderate quantity of gravel of the smaller-sized fragments, however, often covers considerable areas of this soil, both upon the plains and in the valley.

The upland phase of the Maricopa sandy loam generally occurs upon the higher and intermediate slopes of the Great Plains, occasionally extending into the draws and local depressions. In certain parts of the area, particularly south of Rockyford and northward from Lajunta, it is cut by rugged bluffs, terraces, gravel beds, and rock outcrops of the Apishapa and Timpas formations, which frequently cap the summits of the mesas and higher terraces of the area.

The native vegetation of the Maricopa sandy loam consists of buffalo grass and bunch grasses, with the sage, "soap weed," and vegetation of the lighter upland soils in less proportions.

This soil absorbs moisture readily, and owing to its physical structure, usual protection of vegetation, and a thin mulch of wind-blown sand which often covers it, possesses pronounced moisture-retaining properties. The heavier subsoil also plays an important part in maintaining a long-continued supply of moisture to the looser soil above. The compact structure of the subsoil also retards the movement of seepage water from the irrigating canals and ditches.

The natural drainage is good, and the soils are little damaged by seepage waters except when occurring in the draws of the plains and in local depressions of the valley bottoms adjacent to canals and heavily irrigated lands of a loose structure.

The upland Maricopa sandy loam, like the upland sands, owes its origin to the ancient débris-bearing streams of the foot slopes of the Rocky Mountains. These deposits, bearing a somewhat larger percentage of fine material than the sands, have since been greatly modified by stream wash from higher elevations and by intermixture with fine wind-blown material.

The proportion of mica mingled with the quartz and feldspar of this soil is noticeable. The soil contains a moderate but not large amount of organic matter, lime, and the other elements necessary to the growth of plants. It contains an injurious amount of alkali salts only where subjected to the seepage and leaching from the alkali-bearing rocks and soils of surrounding higher elevations. The heavier subsoil, however, sometimes contains a relatively large amount of alkali, and in such places irrigation should be practiced with care. This matter will be treated in a separate chapter.

All but a small proportion of the upland Maricopa sandy loam lying on the south side of the valley is devoted to grazing, the greater part

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consisting of high, rolling land lying above the canal systems. Large areas of this soil type similarly situated, shown upon the Rockyford sheet, extend westward from Holbrook Lake along the north side. Northeast from Holbrook Lake, and extending nearly to Horse Creek, about half of this soil is irrigated, producing excellent crops of alfalfa and sugar beets, wheat, oats, sorghum, and other staple crops of the section. The raising of watermelons, cantaloupes, apples, peaches, and small fruits is also becoming an important and profitable industry. Large and valuable cultivated areas of this soil type occur also upon the other sheets of the area surveyed.

These areas of Maricopa sandy loam, being easily cultivated and producing abundant yields under favorable conditions, are among the most valuable lands in the area surveyed. This soil is well adapted to melons, sugar beets, alfalfa, tomatoes, and truck crops, and the gradual extension of an intensive system of agriculture over such lands seems to be in progress.

In the valley phase the color sometimes becomes of a grayish tint and the texture coarse. When less than 6 feet in depth it is generally underlain by material similar to Fresno sand, Riverwash, or occasionally the heavier types of the valley bottoms. The areas of the valley phase are usually small and much interlaced with river sands and soils of the heavier bottoms. Quite large and uniform areas, however, occur in the vicinity of and northeast from Rockyford and in various portions of the valley bottoms throughout the area. The areas usually occur as slightly sloping elevations or narrow streaks cutting the adjacent soils of the valley terraces.

In the case of the valley phase the formation of this soil is due rather to the more recent deposits of the Arkansas River, the material being originally derived in part from the quartz and feldspar bearing rocks of the mountains and in part from the heavier alluvial deposits of the upper valleys.

The crops grown are similar to, and the yields compare favorably with, those of the upland soil. Owing to its deeper nature and looser texture, however, it usually requires a more frequent irrigation and thorough cultivation in order to guard against excessive losses from evaporation.

The table on the following page gives the results of mechanical analyses of the Maricopa sandy loam.

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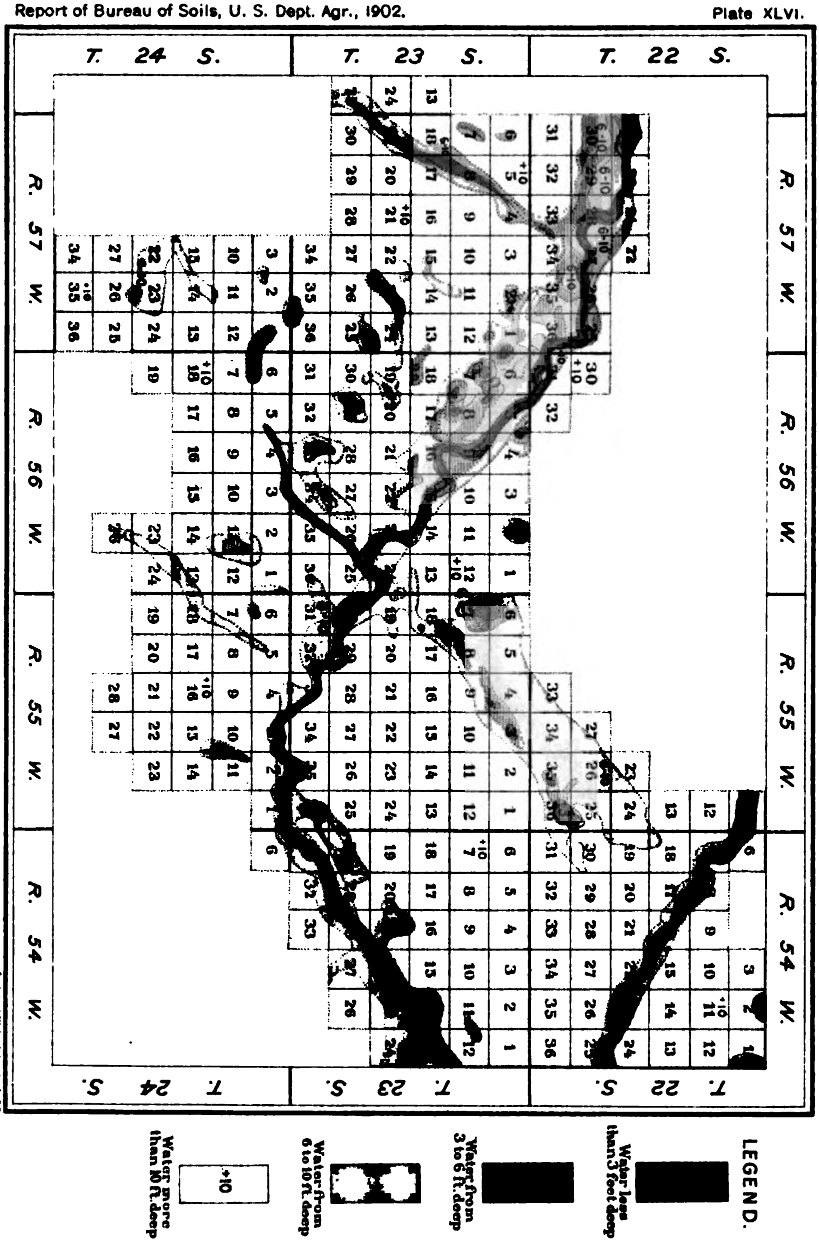
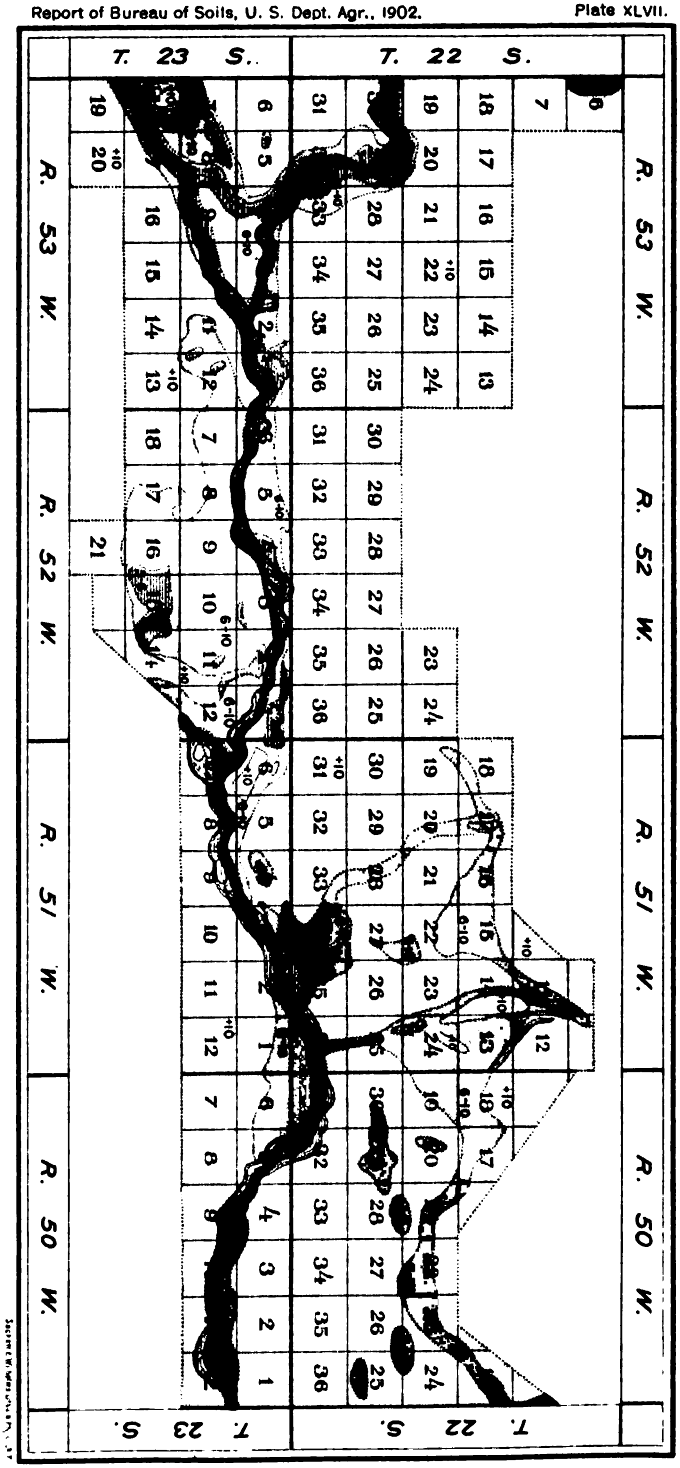


UNDERGROUND WATER MAP. ROCKYFORD SHEET.



UNDERGROUND WATER MAP, LAS ANIMAS SHEET.

Water less than 3 feet deep

Water from 3 to 6 ft. deep

6-10 Water from 6 to 10 ft. deep

+10 Water more than 10 ft. deep

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Mechanical analyses of Maricopa sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7956	Sec. 5, T. 23 S., R. 56 W.	Gravelly sandy loam, 0 to 10 inches.	0.16	7.64	23.40	19.12	20.74	12.38	8.94	7.68
7950	Sec. 8, T. 23 S., R. 55 W.	Sandy loam, 0 to 18 inches.	.80	.10	2.94	10.52	37.22	22.94	13.46	12.82
7954	Sec. 5, T. 22 S., R. 56 W.	Coarse sandy loam, 0 to 12 inches.	.97	.42	4.80	9.74	25.72	31.78	14.44	13.02
7952	Sec. 2, T. 22 S., R. 56 W.	Coarse brownish sandy loam, 0 to 24 inches.	.73	.04	.96	2.54	9.02	27.80	44.28	15.36
7953	Subsoil of 7952....	Sandy loam, 24 to 72 inches.	.49	.52	3.34	9.52	24.82	21.24	20.32	19.28
7951	Subsoil of 7950....	Sandy loam, 18 to 72 inches.	.26	.12	1.00	3.14	21.64	23.58	29.50	20.96
7957	Sec. 2, T. 23 S., R. 56 W.	Sandy loam, 6 to 10 feet.	.79	.38	1.60	2.20	10.90	13.10	37.00	34.82

MARICOPA SANDY ADOBE.

The Maricopa sandy adobe is one of the most important of the upland soils, and, like the Maricopa sandy loam, is subject to variation in texture, physiographic position, and physical properties.

In typical section it consists of a yellowish-brown or reddish sandy adobe, the sand occurring in considerable proportions and being rather coarse in texture. It is usually 6 feet or more in depth and quite uniform in character throughout this profile.

In occasional small and generally oval-shaped areas and fingers the Maricopa sandy adobe sometimes assumes the characteristics of a clay loam, the adobe structure being in this case less marked and the sand normally present giving way in large part to a larger proportion of silt and clay. The color becomes of a brownish or dark-gray tint, and the soil grades into the silt loam and clay loams of the bottoms.

Bodies of the typical Maricopa sandy adobe occur throughout the area surveyed. It is, however, a distinctively upland type and is rarely found upon the uplands of the south side. The areas vary in extent from a few acres to several square miles. They are usually quite irregular in outline and extend as long, narrow fingers through the adjoining areas of Fresno fine sandy loam and Maricopa sandy loam. Unlike the adjacent types, these areas are seldom gravelly, gravel occurring only in small proportions and consisting of fine, angular limestone or shale fragments.

The Maricopa sandy adobe generally occupies the lower levels and draws of the plains. Long, narrow areas frequently follow the course

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of arroyos and drainage basins, and small areas sometimes occur near eroded rock outcrops upon higher terraces.

The areas are unmarked by prominent bluffs or terrace lines and rock outcrops, and the surface is generally smooth and covered with the buffalo grass of the plains. Areas of the clay loam phase of the soil occur in local depressions and drainage basins upon the Great Plains, or frequently as long, narrow fingers bordering the courses of arroyos and minor stream channels. The surface is generally level and devoid of gravel in noticeable quantities. The vegetation usually consists of the bunch grasses and buffalo grass of the plains.

In many local areas, especially where the Maricopa sandy adobe grades into the Fresno fine sandy loam, the coarse sand is wanting and the soil assumes a fine, loamy character. The adobe structure is, however, retained. The color is somewhat lighter and sometimes of a yellowish tint.

Areas of this character often occur in the neighborhood of the disintegrating Cretaceous rocks and upon the higher terraces and slopes of the plains. In this phase the frequent occurrence of fine, angular gravel, white in color and consisting of fragments of shale and limestone rock, is characteristic.

The weathering of the Cretaceous rocks in place seems to have been an important factor in the origin of this phase of the Maricopa sandy adobe, although it has been greatly modified by subsequent stream wash and wind action.

Owing to the compact structure of the Maricopa sandy adobe, water is less freely absorbed and the run-off is relatively greater than with the Maricopa sandy loam. The water-holding capacity and drought-resisting properties under proper and sufficient cultivation are, however, marked. While in its natural condition, with the exception of a few local drainage basins, the drainage is good, many low-lying areas have been damaged by seepage from heavy and frequent irrigation upon surrounding higher levels. Percolation in a soil of this structure takes place slowly, and the removal of seepage and drainage waters must be aided by artificial drainage in order to bring such lands to a state of full productivity.

The sand occurring in the Maricopa sandy adobe seems to be similar in mineral character to that of the other sandy soils of the uplands and was undoubtedly derived from these other soils. The finer sediments have been derived by stream wash from the surrounding uplands and by disintegration of the Cretaceous rocks, particularly the shales. These mixed sediments have been laid down by streams and surface drainage, resulting from heavy rains, in the depressions and lower levels of the plains. In some places sedimentation may have taken place from temporary lakes or stagnant water. The addition of wind-blown material, ranging from fine dust to sand, to these deposits seems

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to have played a less important part in the formation of the soil than in some of the other types.

The sand of the Maricopa sandy adobe consists mainly of well-abraded quartz and feldspathic fragments. Gypsum is very abundant throughout the soil section, occurring as partly disintegrated crystals and flakes, often very nearly pure and imparting a mealy character to the soil. This constituent seems to have been derived largely from decomposition of the shales, but may in part be due to desiccation of concentrated solutions. Lime is usually present in large amounts, and the soil is generally well provided with plant food, although sometimes rather deficient in organic matter.

Like all true adobes, this soil is characterized by its stickiness when wet, its lightness in weight, and its tendency to crack into a system of small, roughly cubical blocks upon exposure to the sun after subjection to heavy rains or puddling. With proper cultivation the structure assumes a looser character and the soil partakes of the nature of a sandy loam. It possesses marked moisture-retaining properties when well handled, and forms an important and valuable soil in the Lower Arkansas Valley area.

The Maricopa sandy adobe is not only relatively rich in the valuable mineral elements, but it also contains a considerable amount of the injurious alkali salts. In its normal condition these are, however, not in a concentrated form and occur only in the subsoil. While a large amount of alkali may be present in this soil, it may be so uniformly distributed and occur at such depths as not to impair the growth of shallow-rooted crops. Such lands have been farmed in this area for years with good profit and no damage from accumulation of the alkali salts within the root zone of crops. With too frequent or excessive use of irrigating waters, however, or with seepage from adjacent canal systems, the underlying alkali salts are sure sooner or later to make their appearance at the surface in a more concentrated form. Many small areas of this land have already been damaged in this manner. For such lands the establishment of thorough artificial drainage, coupled with the judicious use of irrigating waters, is the only remedy.

A considerable proportion of this land is unirrigated and uncultivated by reason of its position. Such areas are devoted to grazing. While good yields of sorghum, corn, wheat, and oats are produced upon the areas of the Maricopa sandy adobe under irrigation, the raising of alfalfa for hay and seed is the principal interest. Excellent yields are obtained, and this line of agricultural industry is a very important and profitable one.

The Maricopa sandy adobe is well adapted to the raising of hay, grains, and all crops of this section requiring a moderately strong, heavy soil. Sugar beets should do well with thorough preparation of the land and careful cultivation.

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The following table gives mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Maricopa sandy adobe.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7948	Sec. 3, T. 23 S., R. 55 W.	Sandy loam, 0 to 12 inches.	1.26	0.30	1.98	4.02	26.78	27.32	24.54	15.18
7946	Sec. 6, T. 23 S., R. 55 W.	Loam, 0 to 12 inches.	.90	.80	2.04	5.64	22.34	23.76	29.84	16.04
7949	Subsoil of 7948......	Sandy loam, 12 to 72 inches.	.41	.10	1.38	2.20	26.00	21.42	24.36	24.60
7947	Subsoil of 7946......	Sticky yellowish loam, 12 to 72 inches.	.25	.62	2.10	5.44	19.64	22.20	24.20	26.02

MARICOPA CLAY LOAM.

The Maricopa clay loam is a very heavy, tenacious clay loam of a dark-brown color, 6 feet or more in depth.

This type occurs only as small areas in the Rockyford, Lamar, and Holly sheets, occupying the lower bottoms of small valleys or recent lake beds. The surface is generally level and unbroken by terraces, rock outcrops, or the occurrence of gravel in noticeable amounts. The native vegetation consists mainly of the bunch grasses and other plants of the heavy bottom lands.

This soil is often subject to the accumulation of seepage waters from the soils of open, porous texture surrounding it, and, owing to its level surface and close, compact nature, the natural drainage is poor. The damage resulting from seepage waters upon the area of this soil near Taylor Lake, shown in the Rockyford sheet, has reached alarming proportions, and a thorough artificial drainage of this land is necessary in order to render it capable of profitable cultivation.

The Maricopa clay loam is made up of the finer sediments washed from the surrounding uplands and probably deposited in still water.

The presence of gypsum in this soil is often very marked, occurring throughout the soil in small granules and flakes to an undetermined depth. The necessary mineral and vegetable plant food is also provided in abundance, and the soil would possess excellent moisture-retaining properties if well drained and properly cultivated. It is, however, very sticky when wet, and dries and bakes badly upon exposure after puddling. Nearly all this body of land has been seriously damaged by the accumulation of alkali salts resulting from the alkaline

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seepage waters of the adjoining lands of higher level. Owing to the close texture of the soil, such salts are removed with difficulty, and a thorough drainage of the land is a necessary preliminary step in its reclamation.

Owing to the presence of the injurious alkali salts, much of this land, at present occupied by a few hardy, alkali-resistant grasses and plants, is used as pasture. In local spots it is barren of vegetation, and, generally, its value for grazing purposes is only nominal.

With thorough drainage and the reclamation of this land by removal of seepage waters and the alkali salts, good crops of alfalfa, sorghum, corn, small grain, and other crops adapted to heavy lands should be grown. During the process of reclamation sorghum and beets would probably prove the crops most beneficial to the soil and most profitable.

The following table shows the texture of the soil and subsoil of this type:

Mechanical analyses of Maricopa clay loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7958	Sec. 3, T. 23 S., R. 55 W.	Heavy, sticky clay loam, 0 to 12 inches.	0.36	0.36	4.08	5.60	11.50	9.54	37.64	31.24
7959	Subsoil of 7958......	Clay loam, 12 to 72 inches.	.32	.10	.86	.72	6.62	8.84	53.42	29.44

FRESNO FINE SANDY LOAM.

The Fresno fine sandy loam is a soil of very fine sandy or silty texture, slightly yellowish in color, and typically 6 feet or more in depth. It is usually quite sticky when wet, bakes slightly during dry weather, and possesses a marked adobe structure. When subjected to stream erosion it washes easily, cleaving vertically into deep arroyos and cuts. Occasionally it is underlain at from 3 to 6 feet by a coarse yellowish sand or sandy clay, but usually it is very uniform in structure and texture to a considerable depth, often extending with but little variation to bed rock.

In the depressions a higher percentage of silt frequently occurs and the soil becomes slightly darker in color, owing to the greater proportion of organic matter.

A valley phase of the Fresno fine sandy loam, which is of alluvial origin, differs from the typical Fresno fine sandy loam in its texture, darker color, lack of uniformity, and position. In this phase the heavy

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percentage of silt is often largely replaced by fine sand. The color frequently becomes of a dark brown, and in depth the soil varies from a few inches to several feet. Like the other soils of the valley bottoms it is usually underlain by the interlaced and lenticular patches of other soils of recent alluvial origin. It is almost all under cultivation, absorbs water readily, is generally free from alkali, and produces the staple crops profitably.

This soil occurs both upon the uplands and upon the upper terraces of the valley bottoms. A much less important phase also occurs in the valley bottoms, usually in close proximity to stream channels.

In the western part of the area the Fresno fine sandy loam occurs only upon the higher terraces and slopes of the valley floor. In the eastern part of the Rockyford sheet it disappears from the valley and makes its appearance upon the uplands. It becomes quite a prevailing and uniform soil type in the vicinity of Lajunta, and the soil areas become more extensive progressively through the Las Animas, Lamar, and Holly sheets to the Kansas State line.

Gravel frequently occurs in the upland areas of this soil type. The fragments are usually small, shaly, or angular in shape. The gravelly areas usually occupy the higher elevations, or occur in the vicinity of outcropping ledges of the Cretaceous limestones and shales from which they are derived. The smooth waterworn pebbles found in abundance in the Maricopa sandy loam rarely occur. Upon the higher slopes the soil areas generally grade into the Maricopa sandy loam and in the depressions into the Maricopa sandy adobe, the Santiago silt loam, or the minor soil types of the bottoms.

In the extreme western part of the area surveyed the bodies of the Fresno fine sandy loam occur upon the gently sloping borders of the valley floor. The surface is smooth and nearly level, but of sufficient inclination toward the valley trough to afford effective drainage.

In the eastern part of the Rockyford sheet and throughout the other three sheets of the area the soil usually occupies the higher and intermediate slopes of the plains, frequently extending into the draws and lower depressions. The soil surface is unusually smooth, of gentle slope, and occasionally broken by outcrops of the Cretaceous limestones and shales. Deep, vertically eroded arroyos sometimes occur.

The native vegetation consists of buffalo grass, sometimes accompanied by the Indian soap weed and other plants of the plains.

With the exception of a small proportion of this soil type lying along the natural draws and drainage depressions, the bodies of the Fresno fine sandy loam are well drained and admirably situated for irrigation. The soil is of a marked close texture, however, and absorbs water somewhat slowly. A large proportion of the rainfall is lost by surface drainage. When once thoroughly wet, however, it retains moisture well. It possesses marked capillary power.

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The drainage of the seepage draws and depressions mentioned must be aided by artificial means to render such lands capable of cultivation and to prevent serious damage or ruin from the accumulation of an excess of the alkali salts. The location of such depressions may be ascertained by a comparison of the soil map (to be found in the accompanying portfolio) and the alkali and ground-water maps, colored Pls. XLV to LIII.

In the origin of this soil the weathering of the Cretaceous limestones and shales appears to have been an important factor. With the progressive weathering of the parent rocks this decomposed material has been transported by local drainage streams to the lower levels. Considerable modification by stream wash and wind action has subsequently taken place.

Mica usually occurs in small but noticeable quantities. Lime is generally present in relatively large proportions, and gypsum is usually quite abundant. Occasionally gypsum occurs in small pockets in this soil in a nearly pure form, imparting to the soil a granular structure, crumbling readily to a powdery or pasty mass. Considerable quantities of the alkali salts are also present, but these are usually found in injurious amounts only in the lower depths of the subsoil and do not impair the agricultural value of the soil, except along terrace edges and in the lower depressions, where the alkali is brought to the surface by seepage waters resulting from excessive irrigation, canal seepage, and imperfect drainage.

The Fresno fine sandy loam is relatively rich in plant food, although sometimes somewhat deficient in organic matter. The results of mechanical analyses are given in the following table:

Mechanical analyses of Fresno fine sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
7964	Sec. 9, T. 23 S, R. 55 W.	Fine sandy loam to sandy loam, 0 to 12 inches.	1.29	0.08	0.76	1.60	9.04	19.18	59.80	9.06
7962	Sec. 18, T. 24 S, R. 56 W.	Fine sandy loam, 0 to 12 inches.	.91	.08	1.10	2.16	8.26	19.02	56.46	12.78
7963	Subsoil of 7962......	Yellowish, micaceous fine sandy loam, 12 to 72 inches.	.36	.08	.40	1.14	4.86	13.78	66.86	12.66
7965	Subsoil of 7964......	Sandy loam to fine sandy loam, 12 to 72 inches.	.47	.30	.50	1.18	6.14	33.48	39.54	19.02

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The Fresno fine sandy loam is one of the most valuable soils of the Arkansas Valley area. In the eastern part of the area, however, owing to the present insufficiency of the water supply, a large proportion of the land is unirrigated and is devoted to grazing. The most of it is capable of cultivation and with the increase and perfecting of the means for storing the flood waters will undoubtedly be gradually brought under cultivation.

Upon the irrigated areas large crops of alfalfa, wheat, oats, corn, sorghum, melons, sugar beets, sweet potatoes, fruits, and all staple as well as special crops of the region are successfully grown.

This soil is especially adapted to the raising of sugar beets, alfalfa, grains, and melons. Fruits, especially apples, cherries, plums, and peaches, do well when properly cultivated and protected by windbreaks. The growing of tomatoes and truck crops for local market and canning purposes could be made a profitable industry.

The soil is easily tilled and with proper and thorough cultivation and irrigation may be brought to and maintained at a high state of fertility and productiveness.

RIVERWASH.

Riverwash varies in texture from fine micaceous sand to coarse sand and gravel, with which waterworn bowlders are frequently mingled. The sand is usually of a white or reddish color and is often drifted about by the winds.

In typical section this deposit is 6 feet or more in depth, the depth being usually greater, except where the bed rocks of the Cretaceous Period outcrop or appear near the surface.

Riverwash, as its name implies, occupies the present or former channels of the Arkansas River and its larger tributaries. It thus occurs as a body from one-eighth to one-fourth mile or more in width, extending throughout the area surveyed, with occasional smaller branches following the course of tributary streams.

Riverwash is usually separated from the bordering soils by well-defined boundaries or terrace lines, but it sometimes grades into the stream-deposited bodies of Fresno fine sand and Fresno sand. It is found only in the bottoms of the valley trough and is with few exceptions devoid of vegetation, only a few weeds and willows finding here and there favorable conditions for growth.

Its mineral constituents are mainly fragments of quartz and feldspar mingled with the finer silt sediments, the whole being deposited from the waters of the valley streams when heavily laden with sediments at times of flood. The deposits are continually shifting and rearranging themselves with every alternating flood, and the stream beds frequently fill with quicksand, rendering fording dangerous or impossible. Riverwash is not only deficient in organic matter and the valuable mineral soil constituents, as well as lacking the proper physical

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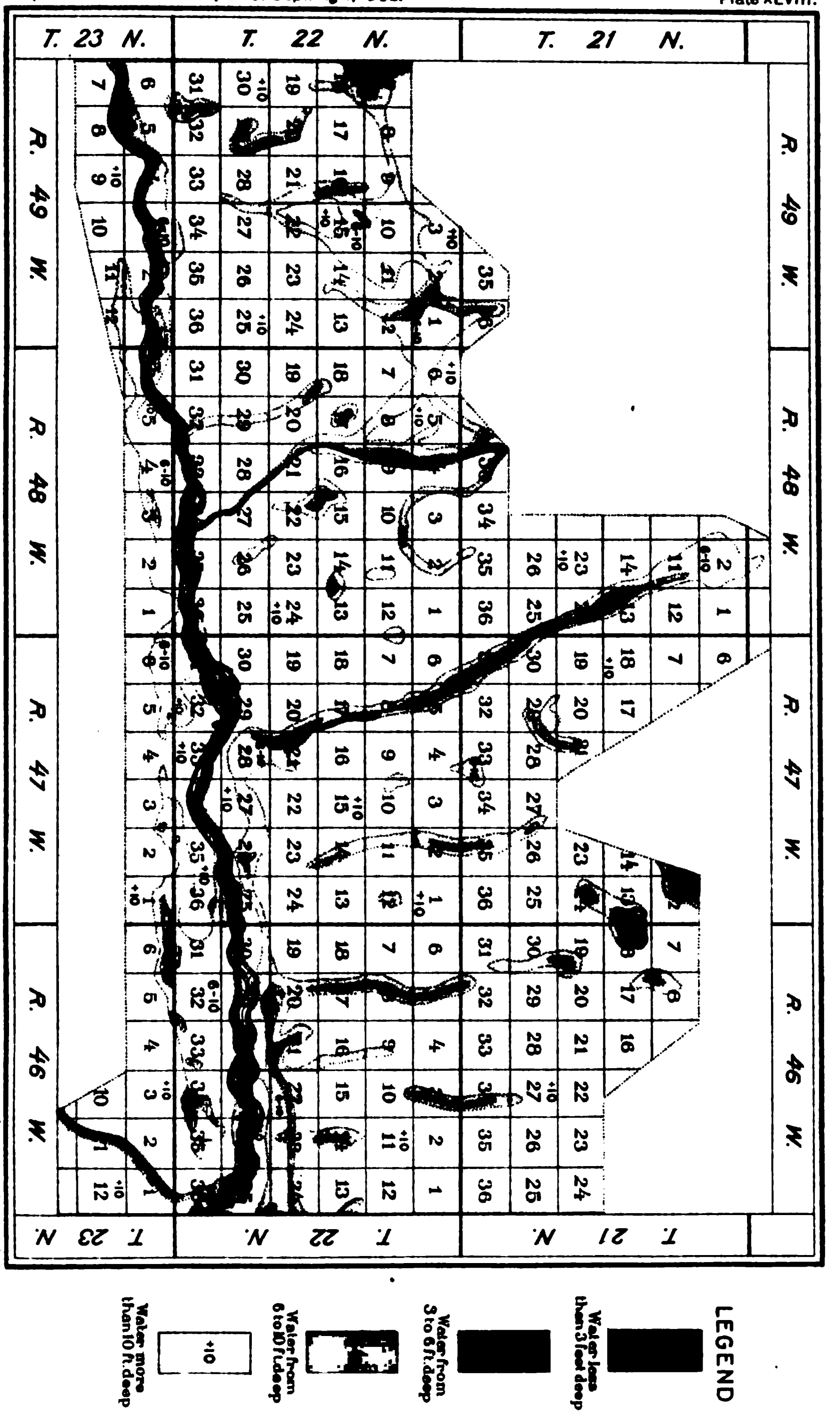

UNDERGROUND WATER MAP, LAMAR SHEET

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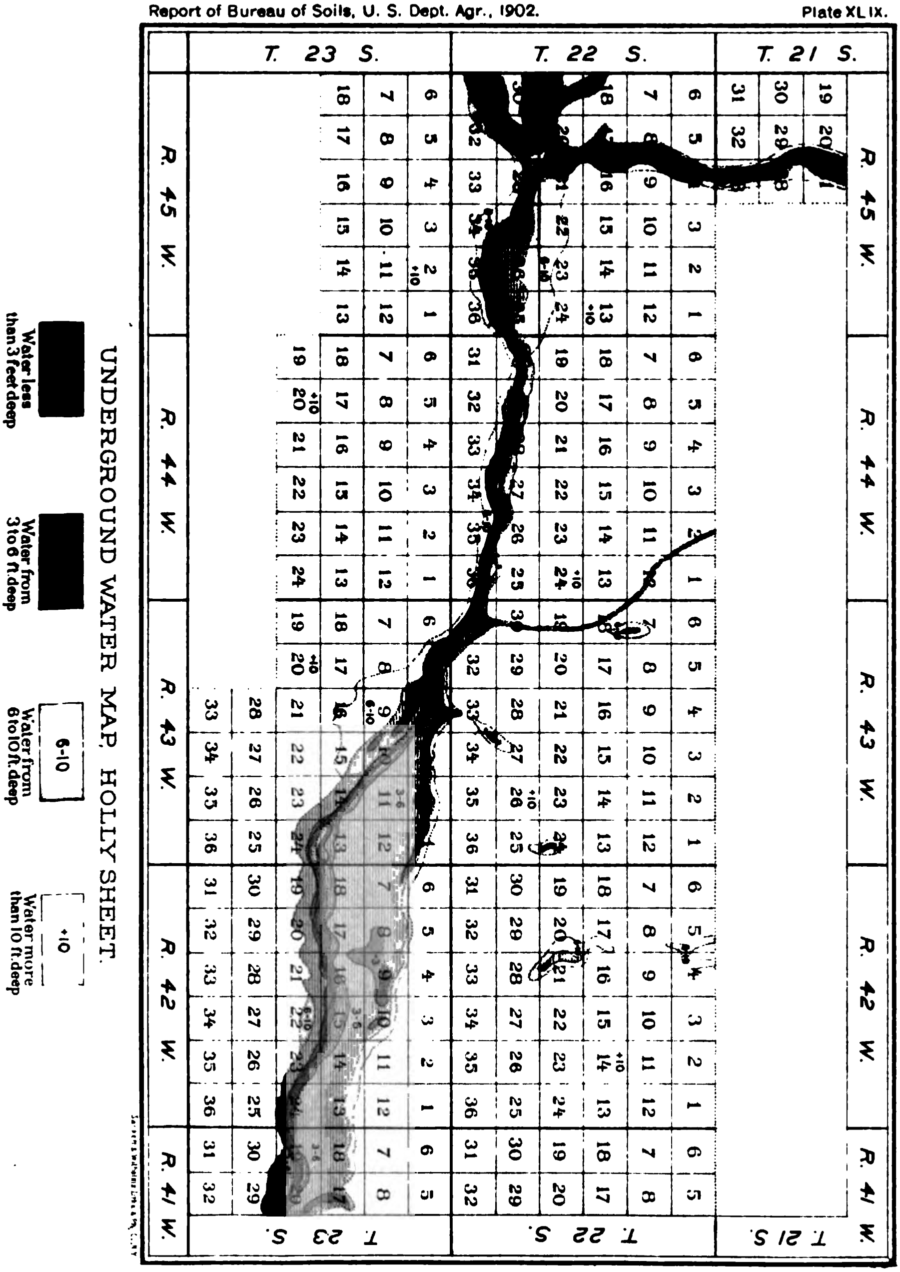

UNDERGROUND WATER MAP, HOLLY SHEET.

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texture, but it is submerged with every passing flood. Hence it is uncultivated and of no agricultural value.

FRESNO FINE SAND.

The Fresno fine sand is a grayish or yellowish micaceous fine sand, varying in depth from a few inches to several feet. It usually occurs as shallow deposits about 18 inches in depth, underlain by coarse sand and gravel or occasionally by the finer and heavier river silts. The areas are often cut by narrow streaks and local patches of waterworn gravel, Fresno sand, Riverwash, and silt deposits, too small to be indicated upon the maps.

The areas of this soil type are generally small in extent, consisting of long, narrow strips adjacent to present or recent stream channels. The soil usually grades into the recent sands and loams of the river bottoms.

The Fresno fine sand usually occurs upon the lower terraces of the Arkansas River and its principal tributaries. The terrace lines are usually well marked, and the surface is generally level or slightly pitted by stream action. A heavy growth of sunflowers and of the less desirable cocklebur, sand bur, and other weeds of the lighter soils frequently cover the areas of this soil type, while in many places the soil supports quite a vigorous growth of cottonwood, some of the trees reaching a considerable size.

The deposits of the Fresno fine sand are usually but slightly elevated above the stream channels and the present water table. The soil is subject to very rapid percolation, however, and when not influenced by seepage from surrounding higher lands or by a water table lying very near the surface requires abundant irrigation during the growing season for vigorous crop growth. Some of the lower areas, however, require drainage for the removal of surplus seepage or overflow waters. The areas are subject to frequent and sudden overflows in times of floods.

The materials of the Fresno fine sand come partly from the mica-bearing rocks of the Rocky Mountains and partly from the finer sands of the river bottoms and stream channels. This material has been deposited in recent times from the moderately slack waters of the streams in flood. More recent modification by wind action has since taken place in many of these soil areas.

The presence of a large amount of mica is a distinctive feature of this soil type, imparting a peculiar mealy and greasy feel to the soil when rubbed between the fingers. Large quantities of this material are deposited upon the lower terraces with every passing flood. The soil is somewhat deficient in both organic and mineral plant food, and this deficiency should be supplied by artificial means for the practice of successful agriculture.

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Normally the soil is free from alkali salts in injurious quantities. In a few cases, however, where small areas are subject to seepage from higher levels, the alkali salts have accumulated at the surface in injurious quantities. Owing to the generally pervious nature of the soil, however, this trouble can generally be remedied by artificial drainage, where sufficient fall can be obtained for the establishment of a drainage system.

The areas of Fresno fine sand are generally reserved for pasture, although occasionally small crops of alfalfa and other staples of the area are grown.

With artificial drainage, the application of stable or green manures, and intelligent cultivation and irrigation fair crops of alfalfa, grain, sweet potatoes, and melons should be produced. These areas are, however, generally subject to overflow during flood periods, and in their present condition are of but little value for other agricultural purposes than grazing. A part of the overflowed lands might be reclaimed by a system of protecting dikes, but, owing to expense of construction and possibility of destruction by floods, this can hardly be recommended under the present agricultural conditions.

SANTIAGO SILT LOAM.

The Santiago silt loam is a heavy brownish silt loam, typically 6 feet in depth, but sometimes only 3 feet, or even less. It is exceedingly tenacious when wet and possesses a marked adobe structure, baking and cracking by intersecting checks upon exposure to dry weather.

The shallower deposits of this soil formation are underlain, usually at about 3 feet, by material similar to San Joaquin black adobe or the Fresno sand and sometimes, when adjacent to stream channels, to the Fresno fine sand.

This soil type is the most extensive type of the lower bottoms. It usually occurs in quite large areas of irregular outline, but occupying the lower lands adjacent to the main streams of the area. These soil areas are somewhat more extensive and uniform in the eastern than in the western part of the area. The soil is quite uniform in texture and structure, but often grades quickly into the other soils of the bottoms and is greatly cut and marked with irregular patches and streaks of the Fresno sand, Maricopa sandy loam, Fresno fine sand, and other adjacent soils. These bodies are generally too small to be indicated upon the soil maps, but are often present to such extent as to influence the productivity and agricultural value of such lands.

The typical soil is quite easily recognized by its position, heavy, sticky nature, and adobe structure, being commonly called adobe in this locality.

Waterworn gravel rarely occurs, except occasionally in the subsoil. Frequently very fine, angular chips and fragments of the Cretaceous rocks appear upon the surface.

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The Santiago silt loam is found only in the valley bottoms, lower stream terraces, and a few of the local depressions and draws. The areas are often separated from the adjacent soils by light terrace lines of recent river formation. The surface is usually level, and the areas are unmarked by outcrops or other topographic features.

The native vegetation consists principally of the bunch grasses, buffalo grass, and plants of the heavier soils, with occasional patches of sunflowers, cockleburs, and other weeds of rank growth. In the western part of the area surveyed this soil type is sometimes covered with extensive and vigorous growths of "greasewood."

The following table gives the mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Santiago silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7966	Sec. 32, T. 23 S., R. 55 W.	Heavy silty loam, 0 to 12 inches.	1.37	0.00	0.32	0.80	6.08	39.34	39.94	13.60
7968	NE. corner sec. 1, T. 22 S., R. 57 W.	Brownish heavy silty loam, 0 to 24 inches.	.94	.84	2.28	2.32	7.88	11.38	30.50	44.62
7967	Subsoil of 7966	Heavy silty loam, 12 to 72 inches.	.72	.00	.18	.18	2.68	34.46	46.76	15.60

Owing to the large proportion of the finer sediments in this soil and to its close texture and impervious structure, percolation and drainage take place slowly. Small areas lying near stream channels are sometimes subject to overflow during freshets. With this exception the greater part of these lands are normally free from water in excess of the amount required by crops, except during periods of heavy rains.

With the extension of irrigation, however, and the formation of resulting seepage springs along terrace lines, the drainage of the lower areas of these lands has become very imperfect. This is true especially of the deeper deposits or those underlain by heavy clay loam. The location of such areas is shown upon the accompanying groundwater maps. The establishment of a thorough system of drainage, preferably by use of tile, is the only means of effectively correcting this evil.

The Santiago silt loam is of alluvial origin, the material being derived by the scouring of the streams along their upper courses. The waters of the Arkansas River and its tributaries are very muddy during flood time, often containing by analysis over 3 per cent of silt. This is deposited in large quantities along the flood plains during high water.

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The Santiago silt loam is rich in both mineral and organic plant foods. Gypsum and lime often occur in abundance, especially in the subsoils of the deeper deposits. These are also often accompanied by relatively large quantities, often amounting to over 1 per cent, of the injurious alkali salts. In the deeper deposits and those not affected by seepage waters or by long-continued irrigation these alkali salts remain in the subsoil and do not greatly affect the native vegetation. These conditions now exist upon large areas of the land covering the western part of the Rockyford sheet.

With insufficient drainage the alkali has in many places appeared at the surface and greatly impaired the land for agricultural uses. In the eastern part of the area surveyed large areas of the Santiago silt loam have a slight accumulation of alkali upon the surface. While in its present condition it has the appearance of containing large amounts of alkali, there is really less proportionally than upon the "greasewood" covered lands of the upper valley.

With proper cultivation this soil should retain moisture well, and should possess valuable capillary properties. Upon exposure during the summer, however, it becomes compact and bakes badly, becoming very hard and dry even with the water table from 3 to 6 feet below the surface. This condition is found throughout the greater proportion of the eastern part of the valley.

A large proportion of the Santiago silt loam bottoms is devoted only to grazing. This is the case especially where the lands have been damaged by alkali or seepage water, and in the eastern sheets, where the water supply is limited.

In the western part of the Rockyford sheet and in the vicinity of the towns throughout the valley valuable and productive farms and ranches are located upon this soil type. The most important crops are alfalfa, sugar beets, the grains, and melons. Excellent yields of these crops are produced during favorable seasons.

This soil is especially adapted to the production of alfalfa hay and seed and sugar beets. Owing to its heavy and somewhat refractory nature, thorough, deep, and frequent cultivation is imperative. These lands, when properly handled, rank with the most valuable beet lands of the valley. Under the same conditions of cultivation and handling, the soil is well suited to the production of watermelons and cantaloupes. This soil is not so well adapted to fruit growing as the lighter types, although apples do well.

SAN JOAQUIN BLACK ADOBE.

The San Joaquin black adobe is a very heavy black clay loam, typically about 3 feet in depth. It is usually underlain by river-deposited sands and silts. The soil is very stiff and tenacious when wet and when dry cracks upon exposed surfaces and assumes an adobe struc-

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ture. It greatly resembles the typical heavy adobes of the Pacific coast.

This is one of the least extensive and important soil types in the area. It occurs in small patches or streaks in the bottoms throughout the area surveyed. It is easily recognized by its position, vegetation, heavy, tenacious nature, and adobe structure. No gravel occurs in this soil type.

The San Joaquin black adobe occurs in local drainage depressions and slough bottoms of the lower valley terraces. The surface is generally smooth and below the level of the surrounding country. The areas are unmarked by rock outcrops, bluffs, or terrace lines. The native vegetation consists of buffalo grass, the common weeds of the heavier soils, and, more often, slough grass and rushes.

The most of the areas of this soil type are poorly drained, the water table being close to or at the surface. The soil is of a very close, heavy texture and percolation and natural drainage takes place very slowly. Many of the small areas in the heavily irrigated sections of the survey have been greatly damaged by seepage waters.

This soil is of alluvial origin, resulting from the sedimentary deposits of ponded streams, small local lakes, and sloughs. These deposits have since been modified by puddling, maceration, and the incorporation of organic matter.

The San Joaquin black adobe in poorly drained areas usually contains sufficient quantities of the alkali salts to impair its agricultural value. Thorough drainage and careful cultivation of these lands are necessary to render them productive.

Owing to position and deficient drainage, but very little of this land is under cultivation. Upon a few of the better drained areas the crops of the heavy silt loam are produced, with fair yields during favorable seasons.

This soil, when thoroughly drained, is best adapted to the growing of sugar beets and alfalfa. (See Pl. XLIII, fig. 1.)

The following table shows the texture of soil and subsoil of this type:

Mechanical analyses of San Joaquin black adobe.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
7960	Sec. 6, T. 23 S., R. 56 W.	Heavy black clay loam, 0 to 12 inches.	2.61	0.16	0.32	0.24	1.16	3.64	47.68	46.80
7961	Subsoil of 7960......	Heavy clay loam, 12 to 48 inches.	1.82	.84	.82	.46	1.54	4.84	52.20	39.30

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WATER SUPPLY FOR IRRIGATION.

The average annual rainfall of this region is generally greater than that of most of the irrigated districts of the West. Dry farming in the Arkansas Valley area has, however, always proven a failure, and can never be recommended for this section.

An irrigation system to prove efficient must be able to supply water at all periods of the growing season whenever the lack of sufficient moisture is indicated by the growing crops. Plants abundantly supplied with water by artificial means during a part of the growing season become pitifully dependent upon such a supply, and when from sudden shortage this supply is denied them suffer accordingly. The necessity for an uninterrupted water supply in irrigated sections is thus obvious.

The State of Colorado is divided into watersheds and again into water districts, each under the charge of a water commissioner. The commissioners serve under the State engineer, an official appointed by the governor of the State. Acting upon reports from gauging stations, the water is apportioned to the different canal systems according to amount claimed and priority of claim. In case of a shortage in the supply all the systems suffer, and a rather complex scheme of loaning or exchanging water is sometimes observed among the canals of a district. This is in a measure doing away with the long-established system of dispensing water strictly according to the doctrine of prior rights, which, although it may be just, does not admit of the most efficient irrigation of the greatest area.

The larger canal systems are each under the control of a canal superintendent. The individual lateral headgates are usually kept locked down, care being taken that each patron is supplied with only such an amount of water as is due him. Under such regulations there is much less danger of immoderate irrigation and the use of excessive and injurious quantities of water than where each patron is left to help himself.

The irrigation waters of the area are supplied by the Arkansas River and its tributaries, and the permanency of water in these streams depends not so much upon the rainfall during the summer as upon the winter snows in the mountains, which slowly melt and furnish a constant supply during the growing season.

The supply is subject to great and sudden variations. Short periods of violent floods alternate with long periods of but little flow. During periods of normal flow but little water reaches the Kansas State line, practically all being taken out for irrigation purposes. The amount of the underflow is undetermined, but is undoubtedly considerable.

The canal and storage-reservoir systems of the area are very extensive. Of the canal systems of the Rookyford or most western sheet of the area, the Rockyford Canal is the oldest and one of the most important. A large share of the melon and beet lands of the valley lie under this canal. Other important systems are those of the Catlin

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Ditch and the High Line and Otero canals. Of these all but the Rockyford Canal have their headgates outside of the area surveyed. Upon the north side of the valley a large section, known as the Holbrook country, is covered by the Holbrook Canal. This is supplemented by the Reservoir Ditch from Holbrook Lake, which is supplied with water from the Holbrook Canal during flood time.

In this area, at least, the storage reservoir is a necessary adjunct to an ideal system of irrigation. By using such a reservoir, where properly constructed and where means for filling the reservoirs during flood periods can be had, a constant supply of water may be maintained during the growing season, regardless of summer droughts.

Within the remaining sheets of the area many small canals water the south side. These are usually in the vicinity of the towns and larger ranches which they water, and are generally of a more or less private nature. Taken as a whole, however, the claims and priorities of these canals are well established, and they cover a large part of the most valuable lands of the valley.

On the north side of the valley the land is covered by the Fort Lyon Canal, operated by the Fort Lyon Canal Company, and by the immense storage reservoir and canal system of the Arkansas Valley Sugar Beet and Irrigated Land Company. This latter system was constructed at a total cost of over $2,000,000 by the Great Plains Water Company, and has been recently acquired by the present owners. This company also owns the greater proportion of the land covered by its own irrigating system in the eastern part of the area surveyed. This land is now being placed on sale.

By arrangement with the Fort Lyon Canal Company the storage reservoirs are supplied with water through the Kicking Bird Canal, which is taken from the Fort Lyon Canal where the latter crosses Gageby Arroyo. There is no irrigated land in the vicinity of the reservoirs nor above the Fort Lyon Canal, the waters of the reservoirs being drawn upon only to supplement the Amity Canal through the Comanche and Pawnee canals and Big Sandy Creek. This canal, with the Buffalo Canal, is owned and controlled by the Arkansas Valley Sugar Beet and Irrigated Land Company.

This system, while of recent construction, is the largest of its kind in the country. Tables giving the capacities of both the canals and reservoirs of the system follow:

Capacities of reservoirs.

Name.	Water unavailable.	Water available.	Total capacity.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*
Nee Sopah	10,908	23,464.50	34,372.50
Nee Gonda	39,860	57,209.00	97,069.00
Nee Noshe	21,485	60,636.50	82,121.50
Nee Skah	9,939	18,279.00	18,279.00
Total	82,192	182,635.60	264,827.60

Length and capacity of canals.

Name.	Length.	Capacity.
	Miles.	*Second-feet.*
Fort Lyon	113.00	2,096.00
Kicking Bird	36.50	1,000.00
Satanta	12.50	300.00
Comanche	16.78	400.00
Pawnee	6.34	200.00
Amity	110.00	870.00
Buffalo	16.10	192.00
Total	311.22	5,058.00

Considerable allowance must be made in the above figures for decrease in capacity of canals due to their filling in with silt deposits.

The system has so far proved a partial failure. The reservoirs are natural lakes or depressions lying considerably below the level of the surrounding country. Consequently a large quantity of water must be supplied to them before any of it can be taken out through the canals and made available for use. The inlet canals are deficient in carrying capacity. The headgates at river inlets sometimes become jammed with logs and flood débris, and when finally cleared the flood is often past. In case of failure to fill the reservoirs during the brief time of the freshets the system becomes useless. The loss of water by evaporation where it lies spread out over a large surface, as it does in the shallow reservoirs, is great, amounting to 6 feet or more in depth over the entire surface. The losses of water from seepage and evaporation from the longer canals are also very great.

Another defect quite common to the canal systems of the area is the matter of cheaply constructed and unstable headworks. This applies especially to the smaller and private canals. Those of the Holbrook and Fort Lyon systems are of a much more substantial and durable character. The headgates and dam of the Amity Canal have in the past given much trouble, especially during the floods of 1902. These are now, however, being replaced by quite expensive and stable structures. Many of the canals of the area have been greatly damaged at crossing points of arroyos and washes. Usually no provision is made at these local draws and drainage channels for the waters which occasionally gather from violent local showers, and these floods often wash large sections of the canals away. There is more or less loss in the capacity of the canals from rapid silting up of the channels by the muddy waters. To avoid this evil considerable fall is usually given to the canals, but even then it becomes necessary to remove the silt from the canals at frequent intervals. In some cases a foot of sediment has been known to accumulate in the canals during a single

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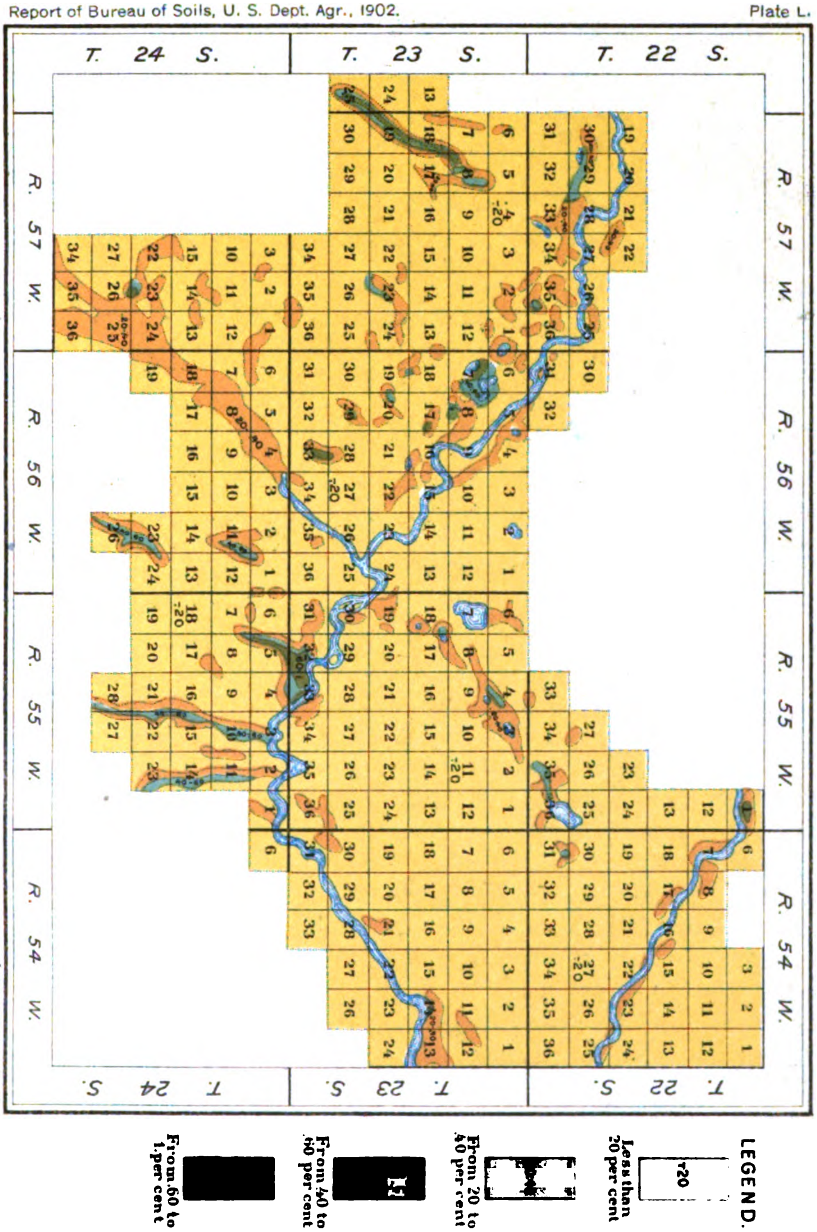

ALKALI MAP, ROCKYFORD SHEET

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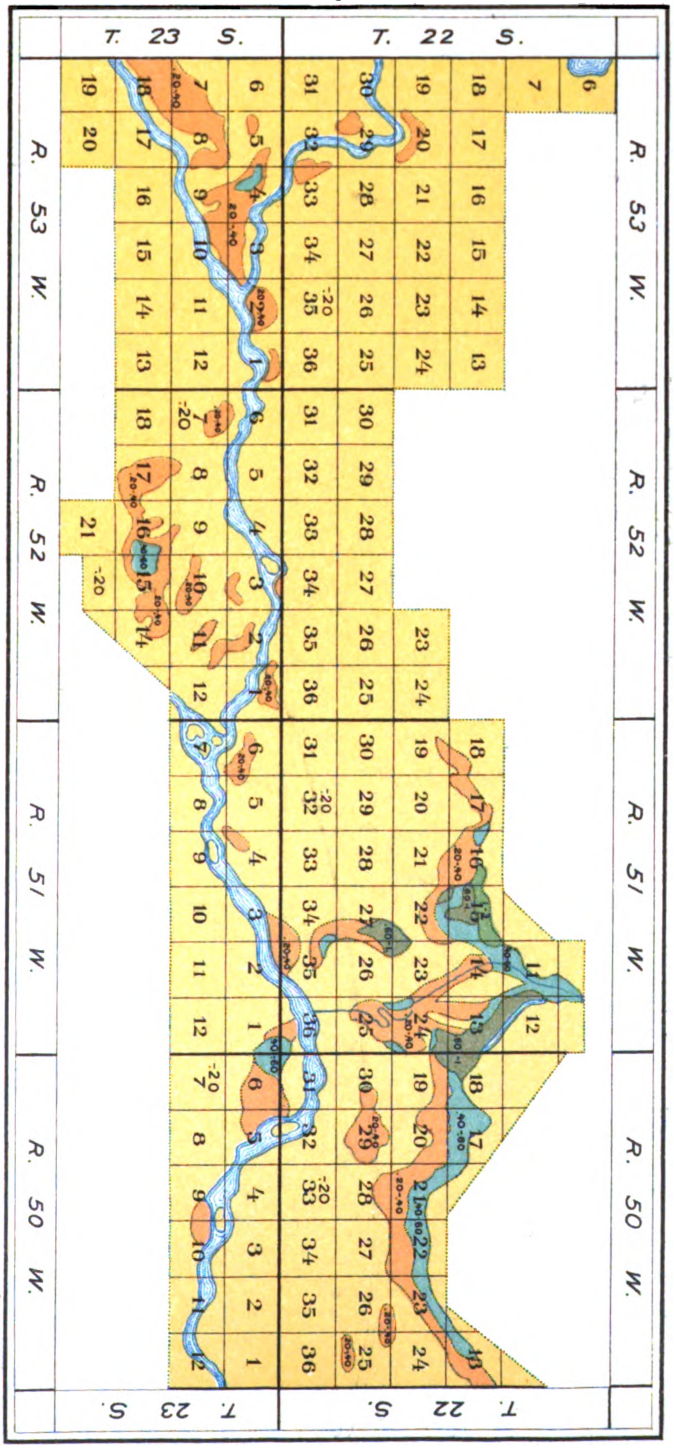

ALKALI MAP, LAS ANIMAS SHEET.

-20 From 0 to .20 per cent

.20-.40 From .20 to .40 per cent

.40-.60 From .40 to .60 per cent

From .60 to 1 per cent

From 1 to 3 per cent

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season. Many of the canals abound in frequent and very sharp curves, which hasten the silting up of the channels at such points.

The Horse Creek Reservoir, supplementing the supply of the Fort Lyon Canal, is of recent construction, and no statements as to its efficiency can as yet be made.

The problem of controlling the flood waters of the Arkansas River and its tributaries is more formidable than seems to be generally appreciated by the constructing engineers; and yet, although past efforts have in a measure been disappointing, the problem is still a hopeful one.

The construction of a few flumes and cut-offs would in many cases greatly shorten the canals and save considerable loss by seepage. Thorough puddling of the canal sides and bottom during construction should be accomplished if practicable, in order to make them as impervious as possible. The necessity of a more thorough irrigation of a small amount of land, rather than the imperfect watering of large tracts, of a more durable construction of headworks and flumes, and of larger inlets to storage reservoirs, is evident. The matter of the preservation of the forests around the headwaters of the rivers is also a most important one and worthy careful consideration by legislators, since the early melting of the unprotected snows of the mountains leads to quickly passing floods and shortage of water during the later season.

Stream measurements have been taken at irregular intervals throughout the valley, but no reliable observations, continuing unbroken for considerable periods of time, are available. The Arkansas River usually has a considerable discharge during the late spring and early summer, supplied largely by the melting of the mountain snows. Of its tributaries, Purgatoire River and Horse and Adobe creeks are the most important within the area surveyed. These streams sometimes have a discharge of several thousand feet during short intervals of flood, but are normally dry or nearly so.

While an immense amount of water is supplied to the area, this is entirely inadequate for the lands under the present canals and capable of irrigation. The extension of irrigation in the Arkansas Valley area must consist of a more abundant supply to lands already covered by canals, rather than the construction of more systems. In the middle and eastern parts only a small proportion of the land capable of irrigation is now successfully cultivated.

The utilization of the Horse and Adobe creek reservoir sites, with a more thorough and careful system of storage, the necessity of which is being more fully realized, will undoubtedly greatly alleviate this condition.

The character of the irrigation waters is an interesting and important subject. All waters taken from the Arkansas River and its tribu-

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taries during flood time are extremely muddy. An analysis of a sample of such water, with the silt which it carries, follows:

Analysis of muddy water from Fort Lyon Canal, Las Animas, Colo.

Constituent.	Parts per 100,000.	Constituent.	Parts per 100,000.
Calcium sulphate ($CaSO_4$)	42.39	Sodium chloride (NaCl)	3.29
Magnesium sulphate ($MgSO_4$)	18.30	Sodium carbonate (Na_2Co_3)	....
Potassium chloride (KCl)	1.69	Sodium bicarbonate ($NaHCO_3$)	19.30
Sodium sulphate (Na_2SO_4)	.60	Total solids	85.60

The analysis of silt carried by water from Fort Lyon Canal shows the principal mineral constituents:

	Per cent.
Percentage of silt in sample of water	3.1
In dry sample:	
Total nitrogen (N)	.15
Phosphoric acid (P_2O_5)	.17
Lime (CaO)	7.48
Potash (K_2O)	.8

This heavy percentage of silt, as previously stated, gives considerable trouble in rapidly silting up the canals and ditches. This is, however, not altogether a disadvantage, as it forms a more or less impervious layer on the bottom and sides of the canals and greatly checks losses from seepage. It is due to this that the muddy waters can be carried for many miles across the loose-textured upland sands, where the clear waters from the reservoirs would be lost through seepage.

The fertilizing value of this sediment is also not to be overlooked. It is very rich in lime, and also contains considerable quantities of nitrogen, phosphoric acid, and potash, as is shown by the foregoing analysis. When several inches of this material are added to the soil in the course of a half dozen years, as often occurs, it is equal in value to many pounds of costly fertilizers. For this reason the silt-laden water of the streams is preferred by farmers to water from the storage reservoirs.

While analysis reveals the presence of a considerable quantity of soluble mineral salts in the waters, these are generally of the less harmful class. With proper cultivation and drainage no harmful results should follow their use. In the case of the reservoir waters a sensible concentration of the soluble alkali salts is sure to result from evaporation. With the full operation of the systems and proper precautions, however, it is believed this will not become a serious problem.

UNDERGROUND AND SEEPAGE WATER.

The source of the artesian water of the Arkansas Valley is the Dakota sandstones. These rocks outcrop over large areas in the vicinity of the mountains, where the main supply is received. In several quite extensive areas near the central part of the area surveyed the Dakota

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sandstones are covered only by the upland sands. A considerable addition to the supply may be received at these points.

As before stated, the strata of the Dakota sandstones are frequently broken. The rock varies also from a loose and open to a more perfectly cemented and impervious texture. The prediction of the quantity of water to be encountered at any point becomes very difficult. Most of the town wells of the area furnish from 50 to 150 gallons per minute at a depth of from 400 to 800 feet. It is only rarely that the pressure is sufficient to produce a flowing well.

The character of the waters also varies considerably, all of them being mineralized to a greater or less extent, depending upon the quantity of infiltrating waters from the Cretaceous shales, which are quite heavily charged with the alkali salts.

Tables showing the results of analyses of samples of the artesian waters of the area follow:

Analysis of artesian water, Las Animas, Colo.

Constituent.	Parts per 100,000.	Constituent.	Parts per 100,000.
Ions:		Conventional combinations:	
Calcium (Ca)	0.69	Calcium sulphate ($CaSO_4$)	2.30
Magnesium (Mg)	5.00	Magnesium sulphate ($Mg\ SO_4$)	24.71
Sodium (Na)	36.30	Potassium chloride (KCl)	1.49
Potassium (K)	.80	Sodium sulphate (Na_2SO_4)	41.40
Sulphuric acid (SO_4)	49.29	Sodium chloride (NaCl)	2.29
Chlorine (Cl)	2.09	Sodium carbonate (Na_2CO_3)	3.60
Bicarbonic acid (HCO_3)	54.24	Sodium bicarbonate ($NaHCO_3$)	74.71
Carbonic acid (CO_3)	2.09	Total solids	150.50

Analyses[a] of artesian water from Lamar, Lajunta, and Rockyford, Colo.

Constituent.	Parts per 1,000,000.		
	First artesian well at Lamar.	First artesian well at Lajunta.	First artesian well at Rockyford.
Lithium chloride (LiCl)		Tr.	3
Potassium chloride (KCl)		12	13
Sodium chloride (NaCl)	55	80	32
Sodium sulphate (Na_2SO_4)	1,030	1,000	671
Magnesium sulphate ($MgSO_4$)	29		
Calcium sulphate ($CaSO_4$)			
Sodium nitrate ($NaNO_3$)		11	67
Sodium carbonate (Na_2CO_3)			2
Ammonium carbonate ($(NH_4)_2CO_3$)	73	72	43
Magnesium carbonate ($MgCO_3$)			1
Strontium carbonate ($SrCO_3$)	104	184	37
Calcium carbonate ($CaCO_3$)		2	6
Ferrus carbonate ($FeCO_3$)		0.2	Tr.
Manganese carbonate ($MnCO_3$)	50	16	12
Silica (SiO_2)			
Total	1,341	1,377	888
Sum of $MgSO_4$, $CaSO_4$, $MgCO_3$, and $CaCO_3$	206	256	80

[a] From report on Underground Waters of the Arkansas Valley, U. S. Geological Survey, G. W. Gilbert.

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Nearly all the towns and larger settlements of the area are supplied with the artesian water of the Dakota sandstone. With this exception, however, there are but few wells. There is no perfect artesian basin, and the possibilities of irrigating with waters of an artesian source are remote. The character of the water for this purpose is often poor, the supply insufficient to irrigate more than a few acres of truck crops, and the cost of pumping prohibitive.

Ground water consists of underground water lying much nearer the surface than artesian waters and not under a head of pressure. The zone of saturation, or the line at which the soil becomes saturated with free water, is known as the water table. When the water table is encountered by wells free water rapidly oozes out, but does not rise in the well above its source. The determining factors in the position of the water table and the amount of water are the rainfall and irrigation, the thickness and porosity of the water-bearing strata, and the position of the underlying impervious rocks and earth. The water table may or may not be parallel to the surface and often fluctuates greatly in position from season to season. This is especially true in heavily irrigated districts, in which the position of the water table is affected by seepage from irrigated lands.

Upon the uplands of the Arkansas Valley area and above the canals the water table lies at relatively great depths. Near the canals, however, and through the valley bottoms it approaches very near to the surface. Its source here is the percolating waters of the rainfall and the seepage springs and underground waters from the canals and irrigated lands. Upon the higher lands and at some distance from the canals the supply is limited. Upon the lower lands and in the vicinity of the canals the wells are usually shallow and supplied with a good flow of water.

The quality of a few of the wells which tap the springs having their source in the upland soils is good. As a whole, however, the character of the ground waters of the area is poor and often unfit for domestic use. For this purpose artesian water from the town or outlying wells, or cisterns filled from the irrigating ditches in flood time, are in general use. The surface wells are often contaminated by organic matter and surface drainage, and the waters are usually too highly charged with alkali salts to be used for drinking purposes.

While large quantities of water of this character underlie the lower lands of the area, the prospects of irrigation by pumping from this source are not encouraging. With the operation of a few pumping plants of sufficient capacity to irrigate a considerable proportion of the lands the supply would probably rapidly diminish. The character of the water is such also as to make its use dangerous. In general, any water so heavily charged with alkali salts as to be unfit for domestic use is unfit for irrigation.

The presence of large quantities of seepage water in an irrigated district is unfortunate, and the removal of such water is an important

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problem. Even its appearance in small quantities is an indication of dangerous conditions. Seepage water results either from loss of water from canal systems and storage reservoirs or from the use of large and too often unnecessary quantities of water in irrigation. The immoderate use of water has always been one of the greatest dangers of irrigated districts. The injury lies not only in the swamping of large areas of the lower lands, but also in the ruin of large tracts from the accumulation of the alkali salts at the surface.

While the damage from the accumulation of alkali and seepage waters in the Lower Arkansas Valley area is much less than in many sections of the West, it is sufficiently serious to create alarm. The position of such seepage areas may be ascertained by consulting the underground water maps (Pls. XLVI to XLIX).

Upon the uplands the seepage areas occur usually as relatively narrow strips bordering canal lines, or as broader areas occupying local depressions, flats, or draws. There is often considerable seepage on the slopes of terraces and elevations, due to the outcropping of a porous layer of soil or rock confined between relatively impervious layers.

The greatest injury has occurred, however, in the bottoms of the main valley and of the many tributary valleys extending outward from it. This is especially true of the draws along which canals extend. In the western part of the area the local depression known as Patterson Hollow is one of the worst affected areas. Eastward from this point many parts of the valley bottoms show similarly bad conditions. Springs carrying a considerable quantity of alkali-laden seepage water are frequent, and many local sloughs and bogs have been formed since the advent of irrigation. In nearly all these localities the conditions seem to be rapidly growing worse, and means should be taken at once to put a stop to the evil.

All of the seepage water contains large quantities of alkali salts, the sulphates and chlorides predominating. The extremely injurious black alkali has been detected, but exists in only very small proportions. The alkali salts in the seepage water are derived from the leaching of the Cretaceous shale rocks and adjoining soils. An analysis of a sample of this shale rock, taken near Rockyford, follows:

Chemical analysis of soluble salts in Cretaceous shale.

[Sample 6622, taken 1¼ miles northeast of Rockyford, Colo.]

Constituent.	Per cent.	Constituent.	Per cent.
Ions:		Conventional combinations:	
Calcium (Ca)	9.77	Calcium sulphate ($CaSO_4$)	21.80
Magnesium (Mg)	2.25	Calcium chloride ($CaCl_2$)	9.77
Sodium (Na)	15.03	Magnesium chloride ($MgCl_2$)	9.77
Potassium (K)	1.50	Potassium chloride (KCl)	3.00
Sulphuric acid (SO_4)	15.79	Sodium bicarbonate ($NaHCO_3$)	55.66
Chlorine (Cl)	15.03	Total salt content	0.266
Bicarbonic acid (HCO_3)	40.63		

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The importance of the drainage of soils in connection with their irrigation is too often unrecognized. Its value is, however, becoming more and more evident. It offers opportunities for the regulation and solution of one of the most serious problems of the arid regions. The introduction of a thorough system of drainage in a district damaged by seepage is productive of many valuable results, chief among which are the removal of bogs and sloughs, the extension of the cultivable areas, and the production of earlier and better crops. It is the only efficient method of reclaiming alkali lands. Drainage also effects a better aeration of the soil and produces conditions favorable to the decomposition of the mineral and organic constituents of the soil, thus increasing the supply of plant nutrients. The reclamation of swamps, with the resulting improved hygienic conditions, and the improvement of the country highways, are also advantages not to be overlooked. The drainage of the seepage areas in this district is generally practicable. The work has already been started in parts of the valley, and the outlook for its extension is encouraging.

ALKALI IN SOILS.

A comparison of the alkali and underground water maps of the Lower Arkansas Valley area shows that in general the areas in which there is a concentration of 0.20 per cent or more of the alkali salts in the first 6 feet of soil coincide very closely with those in which the water table is indicated as lying 6 feet or less below the surface. This relation shows the effect of the seepage waters upon the distribution of the alkali salts in the soil and the accumulation of alkali upon the surface.

In the uplands the soils damaged by alkali occur as relatively narrow strips running parallel with the canals or as broader bodies occupying local draws, flats, or former seepage lake bottoms. A number of alkali areas of the latter class are found in the vicinity of Holbrook Lake, in the Rockyford sheet. Other areas appear in the "Big Bend country," a large section of well-settled and valuable farming land to the northwest of Lamar, covered by the Fort Lyon Canal, and in many other similar localities. Nearly all the draws and secondary valleys have quite prominent slopes, and but little injury has been done to the land in these places, excepting long, narrow strips occupying depressions and following the axes of the valleys. The zone of injury is, however, in most cases rapidly extending upward and outward and encroaching upon the more valuable lands.

In the valley proper the damaged areas usually occur upon the heavier soils of the bottoms. The areas of the Santiago silt loam and the San Joaquin black adobe, from their heavy texture and structure and low-lying position, are most often affected. In the eastern part of

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the area the greater proportion of the Santiago silt loam bottoms contains over 0.20 per cent of alkali, and is devoted mainly to pasture.

In the southern part of the Rockyford sheet several alkali areas covering creek bottoms there shown as containing from 0.20 to 1 per cent of alkali in the first 6 feet have the greater proportion of all the salts in the subsoil. The surface soil is free from alkali, or nearly so. In this condition the lands, although heavily charged with alkali, will produce good crops until the alkali of the subsoil is brought to the surface by irrigation and seepage waters.

Sodium sulphate is the prevailing alkali salt of the Lower Arkansas Valley area. This, with the other common salts of the area, is derived largely from the Cretaceous shales. Sodium chloride is second in quantity and importance, while calcium sulphate, or gypsum, and magnesium sulphate, or Epsom salts, form large proportions of the remaining alkali salts of the region. Sodium bicarbonate is generally found, often in considerable quantities, in the irrigation and seepage waters, but the extremely injurious black alkali, or sodium carbonate, does not exist in harmful quantities in either the soils or irrigation waters. This salt has been detected in solution in seepage waters of poorly drained parts of the area, where it probably owes its formation to conversion from the less injurious bicarbonate through deficient drainage, which favors this chemical reaction.

Under normal conditions the alkali salts of the Lower Arkansas Valley occur only in the subsoil, the rainfall of the region being sufficient to leach them from the immediate surface. With the progress of irrigation, however, the subsoil becomes filled with water and the water table of the lower lying lands is raised. As the irrigation and seepage waters percolate through the soil the readily soluble salts are leached away and carried to the lower lands, and there, with the evaporation of these waters, the material in solution is left upon the surface in the form of an alkali crust. The capillary power of a soil, at times of so much value as a means of supplying moisture to growing crops, may thus become a menace to agriculture by its properties of lifting large quantities of salts in solution to the surface, there to be concentrated by evaporation. This tendency should be checked by the planting of close-growing crops, such, for instance, as alfalfa, which check evaporation by shading the surface, or, better still, by the constant maintenance of a loose mulch of soil upon the surface by thorough and careful cultivation.

In the case of a soil containing alkali only in the subsoil, shallow-rooted crops may for a time be raised with safety. In case of an alkali accumulation upon the immediate surface only, as occurs in many local alkali spots of the valley bottoms, deep-rooted crops, if once started, grow with comparative luxuriance. Heavy irrigation or deep planting are sometimes resorted to as aids in securing germination, after which the plants are less susceptible to the effects of the salts.

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RECLAMATION OF ALKALI LANDS.

Several methods for the reclamation and utilization of alkali lands have been tried. Prominent among these are the removal of alkali crusts by scraping, the washing away of the surface concentrations by heavy flooding, the utilization of partly unproductive lands by special cultivation of alkali-resistant crops, and the application of gypsum to the lands. All of these may, under certain conditions, be of value in aiding the removal of the alkali salts and in rendering the fields capable of cultivation, but in the reclamation of lands containing considerable quantities of alkali they are all inefficient.

The application of gypsum is beneficial, particularly in the presence of black alkali or sodium carbonate. By chemical reaction the less injurious white alkali, or sodium sulphate, replaces the carbonate. This, however, still leaves an excess of the sulphates in the soil. As there is practically no black alkali in the area surveyed, this means of improving the condition of the alkali lands does not apply. There is, also, an abundance of gypsum at the present time in the soils of this area, and it is therefore unlikely that the black alkali will ever give any trouble.

The only method for the reclamation of alkali lands which effects a permanent reclamation is thorough drainage. Its absolute success in lowering the water table, destroying the capillary connection between the underground water and the surface, and in removing in solution large quantities of alkali salts has already been demonstrated, not only by artificial drainage systems but in nature as well. The question of the cost of a system of artificial drainage is, however, the determining factor in its utility for the purpose.

In the Lower Arkansas Valley there are many small tributary valleys or draws, previously mentioned, extending outward into the plains and traversing in many cases the alkali lands. It frequently happens that these local drainage channels are not continuous, though with but slight expense they could be made so by cutting open drainage ditches along their axes. The construction of such ditches would in itself remove a large quantity of seepage water and greatly improve the condition of neighboring lands. For the complete reclamation of the lands, however, a system of lateral drains having their outlet into the main drainage channel should be constructed.

Open lateral drains are somewhat less expensive than tile drains, considering first cost, but the former not only interfere with cultivation, but, in the Lower Arkansas Valley, require frequent cleaning and constant attention, as they fill up rapidly with tumbleweeds, which are blown about in great numbers by the winds, and so are more expensive in the end.

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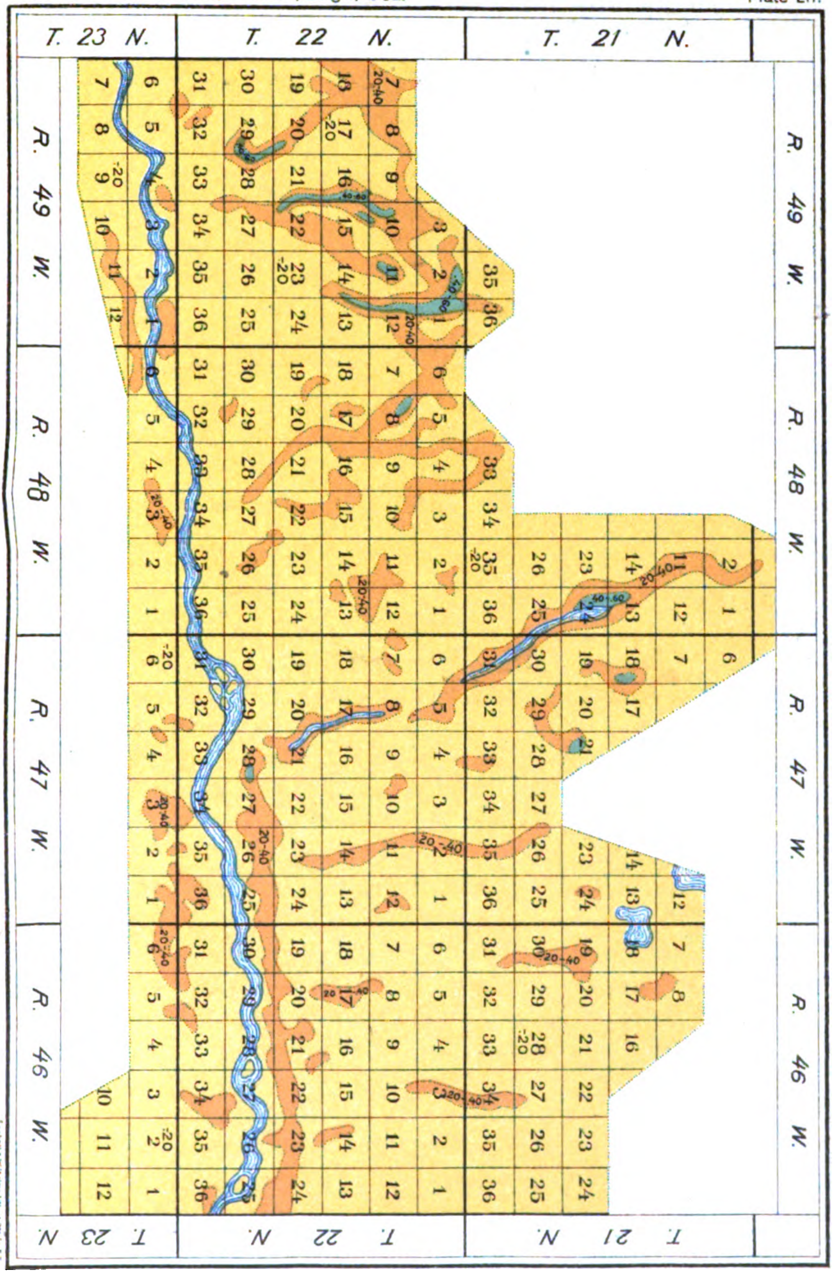

ALKALI MAP, LAMAR SHEET.

LEGEND

-20 Less than .20 per cent

From .20 to .40 per cent

From .40 to .60 per cent

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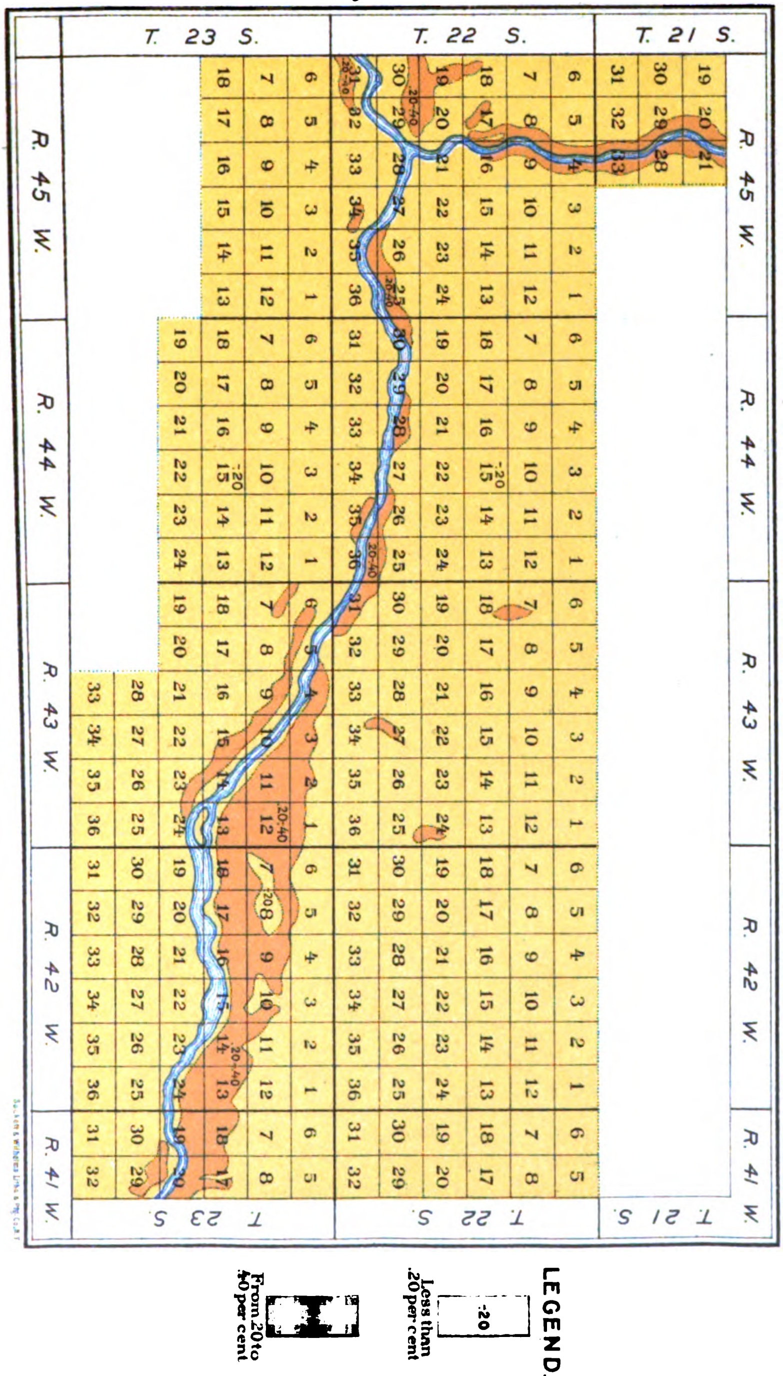

ALKALI MAP, HOLLY SHEET.

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Several examples of tile drainage and its effects may be seen in this area at the present time. These systems have been in operation but a few months, but something of their ultimate success may already be appreciated. The most complete system at the present time is found upon the lands of the American Beet Sugar Company at Rockyford. This was laid out after a preliminary contour survey taken at 6-inch intervals. These plans are now being followed out, and up to the present time several thousand feet of tile have been laid. The tile used vary from 4 to 10 inches in diameter, and are laid at a depth of from 3 to 7 feet. Tile may be purchased delivered at Rockyford in carload lots at a cost of from 2 cents per foot for 4-inch to 7½ cents per foot for 10-inch diameters. The cost per foot of the tile laid upon these lands amounted to from 7 to 11 cents. In laying the system in this tract considerable trouble was encountered with quicksand, which frequently underlies the soils of the bottoms, often to considerable depths. This made it necessary in some cases to use sheet piling for trench curbing while the work was in progress, and to substitute sewer pipe for ordinary drainage tile to avoid displacement by the shifting sands. The sheet piling was in certain cases left in the ground. This, with the use of the sewer pipe, has greatly increased the cost of the work, but it is unlikely that such conditions will everywhere be encountered. The cost of the sewer pipe, second grade, varies from 11 cents per foot for 10-inch to 25 cents per foot for 15-inch pipe. Specially prepared paraffin paper was used to cover the upper portions of the joints in the pipe.

The results of the work have been very gratifying. After extremely heavy rains, the 10-inch tile have been observed to run full for several days. The system resulted in lowering the water table from 1 to 2 feet during the summer of 1902.

After the excess of alkali is removed from the soil, cultivation of the land should be very thorough, keeping a loose mulch of fine earth continually on the surface. Water should not be applied in quantities in excess of the actual needs of the crops. Irrigation by flooding should be generally practiced, rather than furrow irrigation.

With the partial reclamation of the lands the raising of alkali-resistant crops is recommended. Among these, sorghum and sugar beets can be grown as soon as any of the field crops, and besides will allow frequent cultivation of the soil. Later on, alfalfa, corn, and other field crops may be grown.

The alkali lands of this area, when once reclaimed, become the most valuable lands of this section of the country, and in the great majority of cases there can be no doubt as to the profitableness of reclamation, even by the most expensive system of tile drainage.

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AGRICULTURAL METHODS.

The agricultural methods employed in different parts of the Lower Arkansas Valley area vary widely. The agricultural lands range from those under a very intensive system of cultivation to those retained in large tracts and devoted to the growing of alfalfa, stock raising, and grazing. In general, however, the methods of cultivation and irrigation practiced in growing the general farm crops are none too careful.

The character of the irrigation depends very largely upon the supply of water available in the canals at the time irrigation is judged necessary. As in other irrigated areas, considerable waste attends the distribution of the water, and more water is often consumed than is needed by the growing crops, while subsequent cultivation is often lax. Rank growths of weeds are often observed in orchards and in fields of growing crops. In the older and more intensively cultivated portions of the valley, however, cultivation is much more thorough.

Very little commercial fertilizer is used in the area, but barnyard and sheep manure are applied to the fields and green manuring is practiced, usually with alfalfa as the crop to be turned under.

Alfalfa growing is practiced on a large scale, labor-saving machinery being brought into play wherever possible in handling the crop. The warm and generally cloudless weather of the summer season is especially favorable to its growth. The hay is ready to stack very soon after cutting. It is first raked into piles, and these are in turn carried to the stack upon "bull rakes," where it is pushed upon the stacker and lifted by horsepower and placed upon the stack. By this method there is very little hand labor employed.

Three crops of hay are usually produced during the season, the yield averaging about 5 tons per acre for the season in fairly good years. (See Pl. XLIII, Fig. 2.) This will sell for from $3 to $5 per ton in the stack, and, considering the low cost of production, the crop is a very profitable one. Alfalfa is generally irrigated once during the winter and twice during the summer. The growing of alfalfa seed is also an important industry, one crop of hay and one of seed being produced during the season.

In growing melons and sugar beets the methods followed are much more intensive. For cantaloupes the heavier sandy loams having a slight slope are preferred. The soil is often made very rich by green manuring and the application of barnyard manure, a large proportion of organic matter being of value in the production of this crop. The land is then marked out in checks, 8 feet each way for watermelons and 6 feet each way for cantaloupes, the checks then being furrowed one way. About 10 to 15 seeds are planted from 1 to 2 inches deep in hills 1 foot long at intersections of checks, the hills being elevated sufficiently to keep the surface from being flooded during irrigation.

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Frequent cultivating and hoeing is necessary. At the second hoeing the hills are thinned to two plants. The vines are usually lightly irrigated once from one to three weeks after thinning. In planting, every twelfth row is left vacant for a roadway to be used in harvesting.

The cantaloupes are picked when they will slip from the vine easily and are placed in a burlap sack slung across the shoulders of the picker. The sacks are emptied into boxes or crates placed upon sleds and lined with straw or burlap to prevent bruising. Each sled is drawn by a horse to the crating shed, which consists usually of a rude framework of poles covered lightly with branches or burlap sacking. The melons are here carefully inspected and packed in crates 12 by 12 by 24 inches, each crate holding 45 melons of standard size. Perfect melons should be of proper size, shape, and weight, closely netted, with ten distinct ribs and small seed cavity, and should have a flesh of light-green color, slighly yellowish at the center.

The average yield per acre is about 80 crates, although from 150 to 200 or more crates per acre are sometimes produced. The bulk of the shipments takes place between the middle of August and the middle of October. The planting is done from the 1st to the 15th of May, about forty days being required for the melons to reach maturity after they are set on the vines. The crop is shipped through the Melon Growers' Association and commission firms. The average net receipt per crate for the season of 1902 was about $1.

The cantaloupe industry is a very profitable one for growers who live within a radius of 5 miles from a shipping point, and is capable of further extension throughout the valley. Rockyford usually ships from 400 to 500 carloads and the other towns throughout the valley from 50 to 100 carloads per season.

In sugar-beet culture there are no striking departures from the methods used in other areas. Considerable stress is laid upon the necessity for early and deep plowing and thorough preparation of the land, especially when the soil is heavy, and upon securing a smooth, even surface and fine condition of the soil before seeding. As a rule beet culture is carried on somewhat more intensively and successfully in the western than in the eastern part of the area, owing to the greater experience of the growers. The average yield in the former district during the season of 1902 was about 16 tons per acre. The lower valley lands fell considerably below this, owing to an unusual scarcity of water. The sugar content is usually about 17 per cent. The use of too much water, a frequent mistake of less experienced growers, tends to produce shallow-rooted beets of low sugar content. Insufficient and careless cultivation has the same effect.

The rows are commonly sown 18 inches apart, and to sow an acre requires from 18 to 20 pounds of seed. The beets bring an average price of about $5 per ton at the factory.

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Although this is not a grain-producing country, considerable quantities of corn and winter wheat are grown throughout the middle and eastern parts of the area surveyed. Rye and barley are raised, but only to a very slight extent. Except in the area covered by the Rockyford sheet, fruit is grown only in a small way and mainly for home consumption, but this industry is capable of further extension. The planting of wind-breaks of cottonwood and mulberry about the orchards is quite general, and while these afford considerable protection from windstorms the growing fruit is sometimes badly damaged by local hailstorms. As elsewhere, frequent spraying and thorough cultivation of the orchards are important. Apples, plums, cherries, and peaches are best adapted to the soils and climate, although the latter, if unprotected, are often injured by spring and winter frosts. The soil is frequently dug away from the roots of the young bearing trees and the tree bent down and buried under straw for the winter, to protect the tender fruit buds.

Irrigation by flooding is generally practiced where alfalfa and grains are the crops grown, while the furrow method is used in the beet and melon fields. The latter method is somewhat more likely to injure lands impregnated with alkali, owing to the tendency of the salts to creep upward and accumulate upon the ridges and elevations left above the water.

In general, the rotation of crops is not followed as closely as it should be, although more scientific and exact methods of rotation and cultivation are gradually coming in with the development of the sugar-beet and melon industries.

AGRICULTURAL CONDITIONS.

In the more intensively cultivated parts of the area, and in those which have not been held back by restricted water supply, the farming class is generally prosperous. In the middle and eastern parts, however, where a great deal of the land is held in large tracts, where a less intensive and careful system of cultivation prevails, and where the recent unusual shortage of water for irrigating purposes has been most severely felt, the situation is less satisfactory. Many abandoned tracts marked by broken prairie sod, half-completed houses, or cistern or cellar excavations occur, from which the settlers have removed to more favorable locations in the valley or returned to the Middle States, whence the most of them came. The abandonment of the lands is largely due to ignorance of the principles of irrigation on the part of settlers. Many have carelessly taken up lands under proposed irrigation systems which, when completed, have proven inadequate to supply the entire area or have been unable to reach the more elevated lands. The establishment of the more adequate and efficient system

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of water storage now being considered will greatly alleviate this condition and lead to increased prosperity of the entire area.

The farming class is largely derived from the agricultural classes of the Middle Western States. The farmhouses of the newly settled tracts are usually very simple and cheaply constructed, often consisting of rudely built temporary houses or dugouts. These are in the more prosperous districts soon replaced with more substantial and often quite pretentious buildings, frequently of brick or stone. Building stone of excellent character is obtained, at but little expense for quarrying, at many points throughout the valley.

The towns and more thickly settled districts are well provided with churches and good schools. The high schools of the valley towns are the equals of those in much larger Eastern towns. The dwellings of outlying districts are often connected with each other and with the towns by telephone lines, the top wire of farm fences being frequently used for this purpose. Free rural mail delivery is in operation over a large part of the area, and it is not an unusual thing for a farmer living 10 or more miles from town to be in immediate communication with the local markets and shipping points by telephone, and to receive his daily newspaper with almost as much dispatch and regularity as though he resided in the larger towns. This not only leads to more intelligent business methods, but does away with much of the isolation of farm life. Local government is as well organized and the laws are as well enforced as in the more thickly settled districts of the East.

A large number of the farms of the area have been bought through the agency of building and loan associations, water companies, and real-estate brokers. Much indebtedness has been incurred and heavy obligations still encumber the lands in many cases, although the more intelligently farmed districts are rapidly being cleared of debt and the intensively cultivated districts are already largely free from indebtedness.

Good alfalfa, grain, and beet lands with water rights can be bought for from $30 to $50 an acre, but as the towns are approached the value rapidly increases. Fruit, beet, and melon lands adjacent to shipping points in the western portion of the area are valued at from $100 to $200 an acre. The price of land in the middle and eastern parts of the survey is much less than in the vicinity of Rockyford, although under similar conditions of cultivation, water supply, and shipping facilities it should be equally as valuable.

Tax rates are at the present time unusually high, due largely to necessarily expensive construction of bridges throughout the valley, the wagon bridges having been destroyed frequently by floods in the past few years.

Many extensive alfalfa and stock ranches occur throughout the entire survey. These are, however, most numerous in the areas cov-

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ered by the Las Animas, Lamar, and Holly sheets. Excluding these vast tracts, and considering separately the general farming lands, the average size of the farms is about 160 acres. In the intensively cultivated beet and melon districts the tracts are much smaller. With the growth of the intensive melon and beet culture the general tendency is toward the breaking up of the larger ranches and tracts and the substitution of smaller tracts and better methods of cultivation. The Arkansas Valley Sugar Beet and Irrigated Land Company, which is now selling large areas of land near Amity (see Holly sheet), limits the quantity which may be purchased by one person to 40 acres.

Fairly satisfactory farm labor is to be had at a cost about one-fourth or one-third more than is paid in the Middle and Eastern States. In the more mechanical operations of thinning and topping beets and similar tasks the cheaper Mexican or white labor of less responsibility is usually employed. During the recent season a large part of the labor has been cheaply and intelligently performed by Navajo Indians, imported by contract from the reservations for this purpose.

Most of the important crops have already been mentioned. Nearly all products suited to the climate of the area may be produced with success. The growing of Irish potatoes is, however, usually attended with but very poor results, the soil or climatic conditions tending to produce tops rather than tubers. Sweet potatoes yield well. The raising of watermelons for shipment and local consumption is of importance, but is less developed than the cantaloupe industry. Fruit growing is becoming an important industry in the vicinity of Lajunta and Rockyford, the fruit being of excellent quality and finding a ready market. The growing of melon and garden seeds for market is also becoming a profitable and quite extensive line of agricultural development.

Stock raising and stock feeding are very important industries of the area. Many thousand head of cattle and sheep are annually brought in from the range and fattened during the winter. A large proportion of the alfalfa hay of the district is consumed in this manner. Many feeders are now growing large quantities of sugar beets to be used in fattening both cattle and sheep, claiming greater profits than can be obtained by selling the beets to the factory. Large quantities of factory beet pulp are also consumed in feeding. It is estimated that probably 100,000 head of sheep will be fed in the area during the winter of 1902–3.

Honey of excellent quality is produced in large quantities and is shipped extensively to eastern markets, about 12½ cents per pound being obtained for the crop. Unlike the alfalfa honey of some other western districts, the product is white and commands fancy prices.

Truck farming is becoming of some importance in the vicinity of the larger towns and is capable of further extension.

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No unusually serious diseases prevail among the stock of the area, and insect pests and plant diseases are not more numerous nor destructive than elsewhere. Field corn suffers considerably from the ravages of smut, and grasshoppers are at times somewhat destructive to crops, especially in the eastern part of the area.

Several noxious weeds prevail to a troublesome extent, the most common being the Russian thistle, sandbur, cocklebur, and wild sunflower.

In melon culture the rich sandy loams containing plenty of organic matter are preferred. Sugar beets usually produce heavier and richer yields upon the heavier silt-loam bottoms, provided proper precautions are taken in the preparation of the land and the subsequent cultivation. In general, however, the character of the preparation of the land, watering, and subsequent cultivation seem to be of more effect upon both the beet and melon crops than the soils upon which they are grown. (See Pl. XLIV.)

Celery of fine quality may be produced upon the loams of the bottoms if properly cared for, and it would seem that the production of this crop might become of importance. Cucumbers, squashes, pumpkins, and similar crops are said to yield enormously, and the growing of these crops, especially upon the Rockyford fine sandy loam, should become profitable could the crops be handled by canning and pickling factories. The opportunities for the growing of special crops and for diversified farming in this area are promising, and the area will likely in the future become known for other products than its melons, sugar beets, alfalfa, and honey.

The valley is traversed throughout its entire length by the Atchison, Topeka and Santa Fe Railway, which handles a very heavy passenger and freight traffic, both through and local. The early melons are shipped by express and the later by fast freight. Many thousand tons of beets are annually shipped to the Rockyford factory from loading stations along the line. The freight upon such shipments is paid by the sugar company. Freight rates are generally high, and the shipping of produce is rather expensive. Many of the heavy beet-producing districts are also at some distance from the railway, making long hauls necessary and reducing the profits of the grower.

The more thickly settled rural districts are well provided with wagon roads, which are usually kept in good condition. The almost entire absence of mud in the spring is of considerable advantage to the rural districts, as the soil when once thoroughly wet becomes very sticky, making travel very difficult.

In addition to the local markets and those of the East, to which large shipments of melons, alfalfa, and honey are made, the resort, manufacturing, and mining towns of the central part of the State furnish excellent opportunities for the sale of agricultural products.

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The important towns of the area are Rockyford, Lajunta, Las Animas, Lamar, Granada, and Holly. Nearly all of these places have at some time suffered from the inflation of real-estate values by the usual boom methods, but they are now enjoying a more healthful and normal, if slower, growth.

Rockyford is the center of the cantaloupe industry, the seat of the American Beet Sugar Company's factory, having a capacity of 1,000 tons of beets daily, and an important shipping point for fat stock and other agricultural produce. The Arkansas Valley substation, a branch of the State agricultural experiment station, is also located there. The city of Lajunta is the division terminal of the Santa Fe Railway, and the seat of the company's shops. It is also the county seat of Otero County and the location of a large brick and tile plant and other industries. The other towns of the valley are important shipping points for live stock and general farm produce. Lamar supports a large flouring mill, the grain for which is, however, largely shipped in from Kansas points. Another sugar factory is needed in the eastern part of the area and will soon likely be erected at Holly or Lamar, the production of beets at present being equal to or exceeding the capacity of the Rockyford factory. Amity, upon the Holly sheet, is the seat of a rapidly growing colony and a large orphanage under the management of the Salvation Army. The sanitary conditions of these towns is generally good, although improved drainage and sewerage systems are needed in some cases.

To summarize, agriculture in parts of the area surveyed is in a flourishing condition. In other parts it has received a severe check from inadequate water supply and inefficient or careless practices. With improvement in the irrigation systems now under way and the adoption of more scientific methods of irrigation and cultivation the conditions will be much improved in the future. The Lower Arkansas Valley area offers to the careful, industrious home seeker and to the cautious investor excellent opportunities, but is not without dangers for those less conservative or intelligent and industrious.

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SOIL SURVEY OF THE YUMA AREA, ARIZONA.

By J. GARNETT HOLMES.

LOCATION AND BOUNDARIES OF THE AREA.

The part of the Colorado River Valley covered by this survey occupies the extreme southwestern corner of Arizona. The area is a long, narrow strip beginning at the town of Yuma and extending southwest along the Colorado River. It is bounded on the east and south by a bluff or river terrace from 40 to 75 feet high that separates the bottom lands from a high, level mesa. This mesa is cut by the

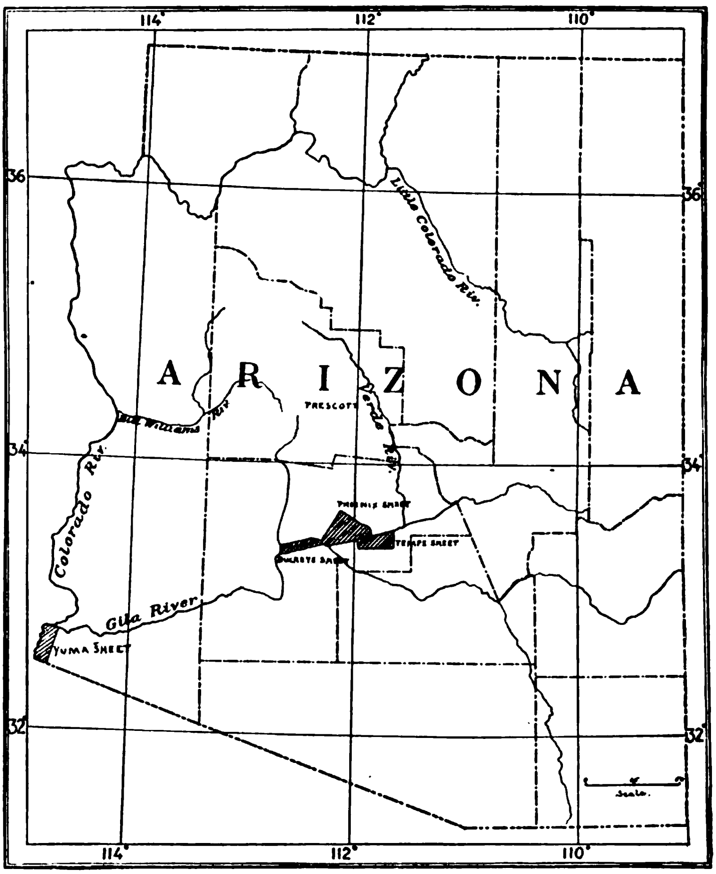

FIG. 24.—Sketch map showing areas surveyed in Arizona.

river at Yuma and comes to within a mile of the river just south of the limits of the survey. Across the river to the northward is the State of California, and west of the river where it flows nearly south is Lower California, a Territory of the Republic of Mexico. The area comprises in all about 100 square miles, or 63,469 acres. (See fig. 24.)

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HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Nearly all the area mapped was originally included in what was known as "Algodone's grant," the title to which antedated the Gadsden purchase, by which this district first became a part of the territory of the United States. There was, however, a strip of land along the foot of the mesa that was never claimed as a part of the grant. Prior to 1891 there was no cultivation of crops in the area, except in a very limited way by Indians and Mexicans on the overflow lands. At this time desert filings were made upon the lands along the mesa outside the grant by those interested in the grant and by a few bona fide settlers. Shortly afterwards a ditch was constructed for irrigation. This was the first organized, well-directed attempt at agriculture. Only the higher portions of the delta were irrigated, and as water could not readily be brought onto the land by gravitation it was lifted by pumping. It was necessary to raise the water from 7 to 15 feet, according to the stage of water in the river. This first ditch afterwards passed into the hands of Eugene Ives and others, and is now known as the Ives Pump Ditch. It is said to divert 3,000 miner's inches. This pumped water is very expensive, costing annually from $7 to $20 per acre, according to the amount of water used.

The next effort at irrigation was near Somerton, about 13 miles southwest of Yuma, where in 1895 J. I. Toler and several others formed a company, sunk several artesian wells, and put in quite an extensive pumping plant. The water-bearing sands, though near the surface, were of too fine texture to allow the water to flow through them rapidly enough to supply the pumps, and the work was abandoned without any land being reclaimed.

In 1897 a few settlers on the Government lands and squatters on the grant in sections 9 to 16 and on adjoining sections in T. 10 S., R. 24 W., associated for the purpose of taking water from the river by means of a gravity canal, through what is known as the American Slough, with a capacity for irrigating 10,000 acres. This system was to be known as the American Canal. In 1899 the original company was absorbed by the Colorado Valley Canal and Levee Company, which did very little work. When, in 1900, the Ludey Canal was being constructed, this canal, with all works and rights, was purchased and became a part of the Ludey system. Although it was and is still the purpose of the American Canal to irrigate 10,000 acres of the overflow lands southwest of Somerton, only about 100 acres have as yet been irrigated. The annual overflow of the Colorado River has greatly damaged the canal as well as the crops. The river will have to be effectually leveed before cultivation can be profitable in this section.

In 1898 a few settlers and squatters in the vicinity of Yuma constructed the Farmers' Mutual Pump Ditch, with head works close to

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those of the Ives Pump Ditch. It is the intention to use water from this ditch to irrigate lands too high for gravity irrigation. The lift is the same as for the Ives Ditch, and consequently the expense for irrigation is about the same, ranging from $7 to $20 an acre per year.

In the same year (1898) there was begun the Farmers' Mutual Gravity Ditch, designed to irrigate 40,000 acres of land in the valley. Work upon this ditch progressed rather slowly, so that it was not until early in 1901 that water was turned into it. Only a small amount of irrigation was done from this ditch, however, for when the June high water subsided the ditch had so filled with sediment that its bottom was above the water level of the river, and as no machinery for cleaning the canal had been provided another long delay was experienced. At the present time (February, 1902) a dredge is being built which is expected to keep the canal free from silt, and the early beginning of permanent irrigation from this ditch is confidently predicted. The keeping of irrigation ditches free from silt is yet an unsolved problem and is, perhaps, the greatest engineering difficulty now confronting the irrigators of lands anywhere along the lower reaches of the Colorado River.

In 1900 the Ludey Canal was begun. It covers practically the same territory in the United States as the Farmers' Mutual, but with the addition of more land farther south in Mexico. The system is planned to irrigate 100,000 acres in all. The first water was run into this canal in 1901, and the same difficulty was experienced as in the case of the Farmers' Gravity Ditch, the head of the canal becoming filled with silt. A hydraulic dredge is now working on the canal, and no doubt water will soon be available for irrigation. The canal has not yet been built to the international boundary line, and success of irrigation with the part already constructed will determine whether or not such extension will be made.

By far the greater part of the valley was originally claimed by the Algodone Grant Company. Squatters came in and settled on the property, and the matter was taken to the courts. After being in litigation for several years the issue was finally decided by the Supreme Court, in 1900, in favor of the squatters. This threw the entire valley open for settlement as Government land. Locations were rapidly made, until now the entire valley has been filed upon, either under the desert or the homestead act.

Several hundred acres of alfalfa have been successfully cultivated in that part of the valley not included in the grant and in some areas within the grant under the two ditches supplied by pumps. Quite a number of farmers are entirely supported from the revenue thus derived from the land. Beyond this there is as yet very little cultivation. Most of the hay is sold in the local market. Very little is marketed in the form of secondary products. The greater number of

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the settlers live in brush and log houses plastered with mud and having dirt roofs. Agriculture is yet in its infancy.

CLIMATE.

The Yuma area is in an extremely arid belt. The rainfall is not only very light, but is also very irregular, so that irrigation alone has to furnish moisture for all kinds of vegetation. The summer is long and very hot, while the winter can hardly be called such at all. The maximum daily temperature in summer ranges from 112° to 120° for weeks at a time, although the nights are usually cool enough to be comfortable. The winter nights are quite cold, ice often forming, but the days are most delightful. Very seldom is a cloud seen. Many of the people live almost entirely out-of-doors and suffer very little discomfort on account of the weather.

Appended is a table compiled from records of the Weather Bureau, showing the temperature and rainfall at Yuma. No other station is situated in the area surveyed.

Normal monthly and annual temperature and precipitation.

Month.	Yuma.		Month.	Yuma.	
	Temperature.	Precipitation.		Temperature.	Precipitation.
	° F.	Inches.		° F.	Inches.
January	53.9	0.42	August	91.6	0.35
February	59.0	.51	September	84.2	.15
March	65.1	.26	October	72.5	.28
April	70.5	.07	November	62.7	.29
May	77.8	.04	December	57.3	.46
June	84.8	.00	Year	72.6	2.97
July	91.5	.14			

PHYSIOGRAPHY AND GEOLOGY.

The valley as a whole is a plain gently sloping to the southwest, broken only by the local occurrence of sand dunes, gullies, lagoons, or old river beds. These minor departures from grade interfere with agriculture chiefly in that they make preparation for irrigation expensive. In some places, as in the areas where sand dunes are mapped, economical cultivation is at present impracticable, but most of the land requires very little leveling to prepare it for irrigation.

This area forms a part of the eastern upper end of the Colorado River delta. The entire valley is made up of sediments, and consists of a great bed of sand, overlain and interstratified with layers of finer material, left by the river as it shifted its course from one side of the valley to the other. The soils are not directly traceable to the rock whence they were derived, as the Colorado drains an immense

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area and has a great number of tributaries, any one of which may be chiefly responsible, at different seasons, for the sediment carried by this lower part of the stream. About 75 per cent of the lands of the valley are overflowed and a layer of sediment added to the soil each year. The deposition has been much greater near the present stream bed than farther back, so that the lands immediately bordering the stream are higher and covered by only a few inches of water during the flood season, while those farther back may in places stand under 7 or 8 feet of water. (See Pl. LIV.)

SOILS.

The soils of the valley have a common origin, and therefore differ mainly in texture. As a result principally of this difference in texture the soils are now found to contain widely varying amounts of soluble mineral matter and humus. All of the soils, even the heaviest, are underlain at a few feet by sand, which extends to unknown depths. This sand is in places quite coarse, but the greater part is very fine and of the nature of quicksand. When this very fine sand is found on the surface, it forms the fine sandy loam.

The following five types of soil were recognized, the areas of which are outlined on the accompanying map: Imperial sand, Imperial sandy loam, Gila fine sandy loam, Santiago silt loam, and Imperial loam. The area of each of these in acres and the proportion each forms of the total area are brought out in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.
Imperial loam	20,800	32.8
Gila fine sandy loam	17,038	26.8
Imperial sandy loam	12,806	20.2
Imperial sand	9,062	14.3
Santiago silt loam	3,763	5.9
Total	63,469	....

IMPERIAL SAND.

The Imperial sand occupies about 14 square miles, or 14.3 per cent of the total area surveyed. It is found skirting the sandy mesa and in isolated areas throughout that part of the valley that is not subjected to overflow. Excepting the dunesand phase of this soil, the surface is comparatively level. Along the mesa the soil is formed directly by the wearing down of the mesa, the sand as the coarser product of weathering being deposited along its base. The other areas are of river sand that, unlike the same material over the greater part of the valley, has no covering of finer sediment deposited upon it. Every rainfall of any extent adds to the sand soil along the mesa, showing plainly its process of formation.

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The Imperial sand is a loose, incoherent reddish-brown sand. Along the mesa it is in places not more than 3 or 4 feet deep, underlain by a sandy loam; the sandy loam subsoil representing the soil that was formed by the admixture of sand from the mesa and loam from the river when the overflow reached the base of the mesa. The sand has since been deposited upon this sandy loam. The action of the wind has transformed large areas of this valuable sand soil into dune lands, with sand dunes often from 5 to 20 feet high.

The cost of leveling such land, with level land at the present prices, would not pay, and the development of these rougher areas will naturally be postponed until the more level areas have been brought under cultivation and values have risen to a point that will warrant the investment of the considerable amount of money necessary to fit the soil for irrigation.

Alfalfa is the only crop that has been grown commercially upon this soil, although it is an admirable soil for the growth of truck crops, such as sweet potatoes, melons, onions, etc. Like most sandy soils, it is well drained and free from alkali.

The following mechanical analyses show the texture of this type of soil:

Mechanical analyses of Imperial sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6507	Center S. side No. 15–40, sec. 1, T. 9 S., R. 24 W.	Sand, 0 to 60 inches.	0.31	Tr.	0.77	0.83	61.64	27.76	6.77	2.23
6506	SE. corner No. 14–40, sec. 18, T. 9 S., R. 23 W.	Sand, 0 to 48 inches.	.26	Tr.	.29	1.26	35.20	43.00	16.15	4.15

IMPERIAL SANDY LOAM.

The Imperial sandy loam, like the Imperial sand, is situated principally in the part of the valley not at present subject to overflow. The surface of this soil is usually comparatively level, requiring very little work to prepare it for irrigation. It has been formed by the admixture of sediment from the river with coarser material transported from the higher land surrounding the valley.

This soil is a loose, friable brown sandy loam of good texture, easy to cultivate, and requiring little cultivation to maintain good tilth. It is usually underlain by sand at a depth of from 3 to 4 feet. In

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some places, however, 2 or 3 feet of loam intervene between the soil and the sand subsoil.

The water table of the entire valley is high, being on an average but 10 feet below the surface, and this soil, owing to a high capillary power, has in places accumulated considerable alkali. Not only has the soil a high capillary power, but water moves through it quickly, making the total amount of water evaporated from its surface quite large. For these reasons, if the soil is left uncultivated the accumulation of alkali is rapid, but under cultivation with irrigation the accumulation is avoided by the presence of the surface mulch and the ready leaching out of the salts.

Alfalfa, sorghum, barley, and kindred field crops are the only ones that have as yet been grown to any extent on this soil. (See Pl. LVI.)

The following table gives the mechanical analyses of this soil type:

Mechanical analyses of Imperial sandy loam.

No.	Locality.	Description.	Organic matter	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6509	NW. corner No. 1-40, sec. 26, T. 8 S., R. 24 W.	Sandy loam, 0 to 72 inches.	0.77	0.00	0.08	0.21	1.48	15.90	76.00	6.30
6508	Center S. side sec. 20, T. 8 S., R. 23 W.	Sandy loam, 0 to 60 inches.	.67	.00	.00	.32	1.37	17.40	67.50	13.42
6511	E. side No. 9-40, sec. 12, T. 9 S., R. 24 W.	Sandy loam, 0 to 72 inches.	.38	.00	Tr.	.42	1.57	12.98	69.20	15.80
6510	Center W. side sec. 20, T. 9 S., R. 23 W.	Sand, 36 to 72 inches.	.11	.00	.10	.71	45.75	35.09	14.87	3.46
6512	W. side No. 13-40, sec. 36, T. 9 S., R. 24 W.	Clay, 36 to 72 inches.	.63	Tr.	.26	.43	1.55	3.28	50.43	44.12

GILA FINE SANDY LOAM.

The Gila fine sandy loam is found in a long, narrow strip skirting the river, and in other parallel strips which probably represent the margins of former river courses. The surface is level and usually covered with a dense growth of arrow weed, willows, etc. This soil is formed of the particles of sediment first deposited by the overflow water, the finer particles of silt and clay being carried farther inland or downstream and deposited in stiller water.

The Gila fine sandy loam is a fine sand having the properties of a sandy loam. The particles are nearly all of uniform size, making a soil of high capillary power and one through which water not only moves long distances but also with great rapidity. It is easily culti-

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vated and remains in good tilth for a long time. The surface soil is from 3 to 20 feet deep and is underlain by a coarser river sand.

Owing to its high capillary power and the nearness of the water table to the surface over most of the areas of this soil, the greatest care must be taken to prevent the rise of alkali after the removal of the natural vegetation. With proper care, however, it should be one of the most productive soils of the valley.

Crops of almost any kind suited to the climate do exceptionally well on this soil. Alfalfa is the principal crop grown. Very little of this soil is at present under cultivation.

The following table gives mechanical analyses of this type of soil:

Mechanical analyses of Gila fine sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6500	N. side sec. 33	Fine sandy loam, 0 to 36 inches.	0.63	0.00	Tr.	0.13	8.04	43.00	44.06	4.34
6501	SW. corner No. 2–40, sec. 25, T. 8 S., R. 24 W.	Fine sandy loam, 0 to 72 inches.	.54	.00	0.10	.10	3.36	38.70	51.50	6.27

SANTIAGO SILT LOAM.

Like nearly all the other soils of the valley, the Santiago silt loam is composed of deposits laid down by the Colorado River. It differs from the Gila fine sandy loam only in that the particles of soil are finer, being the intermediary soil between the Gila fine sandy loam and the Imperial loam. It is well decomposed, contains much organic matter, and is very rich in plant food. The surface covering of grayish to dark-brown friable silt loam has a depth of from 18 to 30 inches and is underlain by fine sandy loam or sand. Taking into consideration the shifting nature of the river and the fact that all the overflow lands are constantly subjected to change, the existence of areas of this and other soils in the overflow part of the valley may not be at all permanent. A few years of deposition of loam or sand, caused by a change in the bed of the river, would be sufficient to obliterate present soil boundaries and necessitate reclassification.

Only about 6 square miles of the Santiago silt loam were found in the valley, the occurrence of the type, as shown on the map, being limited to a small district in the neighborhood of the large bend in the river. This soil has a level surface and in its natural condition is

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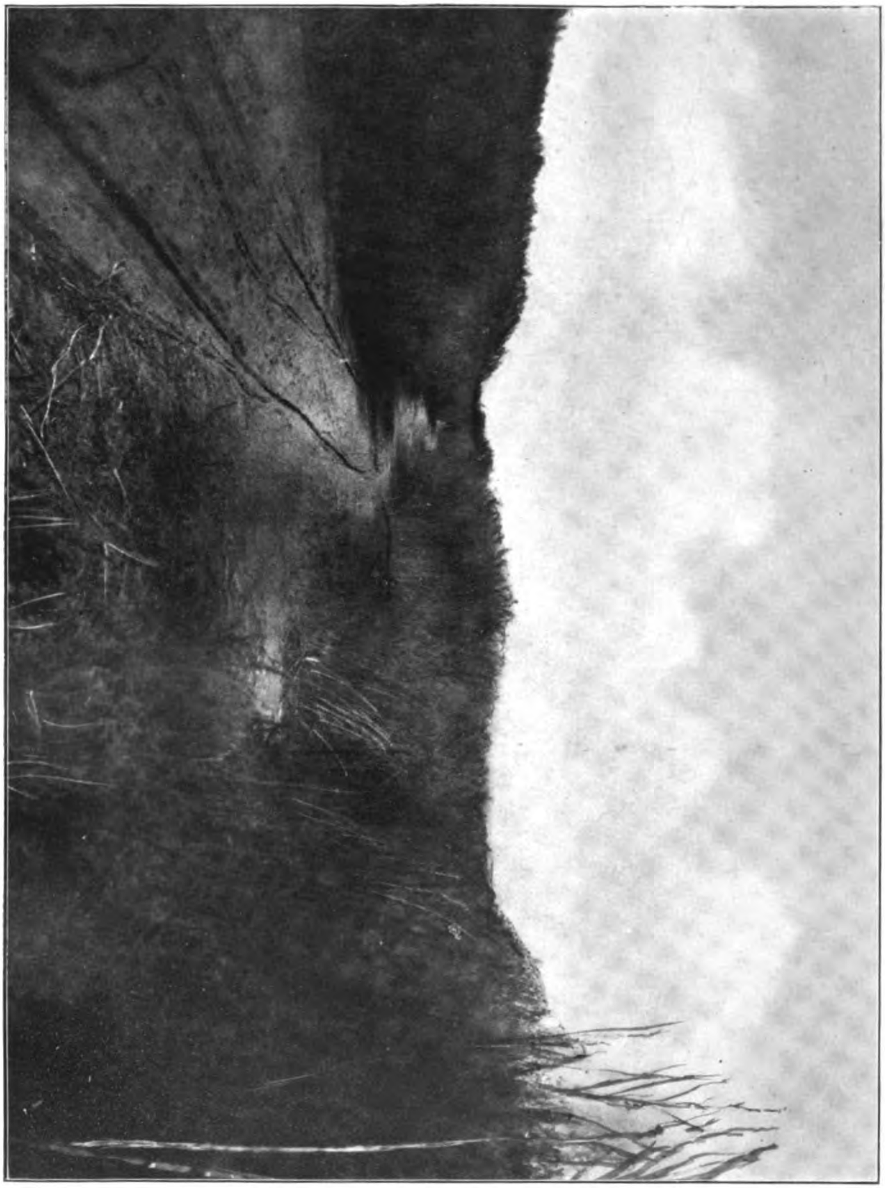

OVERFLOW LANDS, SHOWING DENSE GROWTH OF WILD HEMP, YUMA AREA, ARIZONA.

This is the character of land now being taken up for irrigation.

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OVERFLOW LANDS, SHOWING A DENSE GROWTH OF MESQUITE, SCREW BEANS, AND WILD GRASSES, ADAPTED TO PASTURAGE, YUMA AREA, ARIZONA.

This is the character of lands now being taken up for irrigation.

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ered with wild hemp, arrow weed, annual grasses, and willows. A small proportion of the Santiago silt loam contains injurious amounts of alkali and nearly all contains at least a small amount.

None of this soil is now cultivated, but experience with like soil in other regions has shown it to be well suited to all common field crops, as well as to some special crops. It is on a similar soil in Orange County, Cal., that most of the celery produced in that county is grown,[a] while it is one of the most important bean soils of Ventura County, in the same State.[b]

The following table shows the texture of this type of soil:

Mechanical analyses of Santiago silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6514	SW. corner sec. 31, T. 9 S., R. 24 W.	Silty loam, 0 to 24 inches.	2.17	Tr.	0.10	0.17	0.50	2.34	82.54	14.35
6513	W. side No. 5-40 sec. 6, T. 10 S., R. 24 W.	.....do.............	1.70	Tr.	.22	.22	.84	4.46	70.60	23.68

IMPERIAL LOAM.

The Imperial loam occupies by far the largest proportion of the area surveyed. Wherever the overflow water is comparatively still for any length of time this soil is deposited, and hence most of it is found as a covering for the other soils of the overflowed district. Its surface is comparatively level, except for the intersecting gullies and channels. Should the overflow area be protected by embankments, very little difficulty would be experienced in leveling the entire area of this soil for irrigation.

The Imperial loam is a sticky, plastic, chocolate-brown loam, composed of finely divided particles of mineral matter and a considerable proportion of organic matter. The surface soil ranges from 1 to 6 feet in depth and is underlain by a coarse to fine sand. Much of the soil that is not overflowed already contains an excessive amount of alkali, and wherever the soil is 5 feet or more in depth the greatest care must be exercised if future accumulation is to be prevented. It is the soil most liable to become alkaline under cultivation and irrigation.

[a] See Report on Field Operations, Bureau of Soils, U. S. Department of Agriculture, 1900.

[b] Ibid., 1901.

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Some small areas of this soil lying above high water have been successfully cultivated to alfalfa, sorghum, and other field crops. The type is well adapted to the growing of wheat, corn, and alfalfa when cut for hay and not pastured. When used for pasture the soil packs very hard and the alfalfa is killed. At present the greater part of the area of this soil is overflowed annually and can not be cultivated with any certainty of success until this water is in some manner kept off.

The following table shows the texture of this type of soil:

Mechanical analyses of Imperial loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6505	Along international boundary line.	Loam, 0 to 24 inches.	1.54	Tr.	0.17	0.17	3.48	17.90	56.90	21.35
6502	Center S. side No. 13-40 sec. 36, T. 8 S., R. 23 W.	Loam, 0 to 36 inches.	.10	Tr.	.19	.08	2.39	12.87	53.90	30.90
6504	Near center sec. 2, T. 9 S., R. 24 W.	.....do..............	.35	Tr.	.30	.25	1.96	8.65	57.20	31.65
6503	Subsoil of 6502......	Clay loam, 36 to 72 inches.	.72	Tr.	.11	.11	.86	7.79	58.63	32.50

ALKALI IN SOILS.

At the time that the soil survey of this area was made an alkali map was also prepared, showing the location and extent of areas of the different grades of alkali soil and the amount of alkali in the first 6 feet of soil. The map, which accompanies this report, shows by distinguishing colors the land which contains less than 0.20 per cent, from 0.20 to 0.40 per cent, from 0.40 to 0.60 per cent, from 0.60 to 1 per cent, from 1 to 3 per cent, and over 3 per cent of alkali. The boundary lines between these areas of different alkali intensities were carefully established by work in the field.

A reference to the alkali map will show, as has already been stated elsewhere, that the greater part of the alkali land is situated just above the high-water line of present overflow, where evaporation from the surface has taken place without any surface flooding, showing plainly that the alkali is the result of the evaporation of the river water. Other alkali areas are found along the foot of the bluff, being caused by a small amount of seepage from the high lands above.

Much of this alkali is found in very sandy or fine sandy loam. If proper drainage is maintained this land can be reclaimed by a few heavy surface floodings.

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Appended are a number of chemical analyses of crust and soils from this area, made in the laboratories of the Bureau:

Chemical analyses of salts in alkali soils.

Constituents.	6501. SW. corner No. 2-40, sec. 25, T. 8 S., R. 24 W.; fine sandy loam, 0 to 72 inches.	6506. SE. corner No. 14-40, sec. 18, T 9 S., R. 23 W.; sand, 0 to 48 inches.	6504. Near center sec. 2, T. 9 S., R. 24 W.; loam, 0 to 36 inches.	6503. Under No. 6502; clay loam, 36 to 72 inches.	6509. NW. corner No. 1-40, sec. 26, T. 8 S., R. 24 W.; sandy loam, 0 to 72 inches.	6502. Center S. side No. 15-40, sec. 36, T. 8 S., R. 23 W.; loam, 0 to 36 inches.	6511. E. side No. 9-40, sec. 12, T. 9 S., R. 24 W.; sandy loam, 0 to 72 inches.	6517. Center N. side sec. 27, T. 8 S., R. 24 W.; alkali crust, 0 to 1 inch.
Ions:	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Calcium (Ca)	9.42	5.18	2.72	1.74	9.02	5.27	3.87	2.04
Magnesium (Mg)	2.53	.99	1.27	1.43	4.45	2.49	2.07	1.96
Sodium (Na)	11.23	24.54	27.80	29.25	17.66	25.03	29.29	32.04
Potassium (K)	11.60	4.38	4.17	3.97	3.34	3.58	1.14	2.10
Sulphuric acid (SO_4)	28.26	32.96	18.51	13.68	18.26	14.64	14.07	4.66
Chlorine (Cl)	21.74	22.39	35.73	41.35	43.93	46.36	47.60	56.98
Bicarbonic acid (HCO_3)	15.22	9.56	9.80	8.58	3.34	2.63	1.96	.22
Conventional combinations:								
Calcium sulphate ($CaSO_4$)	32.25	15.34	9.07	5.88	25.83	17.86	13.09	6.61
Magnesium sulphate ($MgSO_4$)	6.88	4.78	6.17	6.99	.00	.00	6.00	.00
Potassium chloride (KCl)	22.10	8.36	7.98	7.63	6.34	6.81	2.18	4.00
Sodium chloride (NaCl)	13.77	30.09	52.71	62.18	41.98	59.17	72.68	81.15
Sodium bicarbonate ($NaHCO_3$)	21.02	13.14	13.36	11.76	4.56	3.58	2.67	.28
Sodium sulphate (Na_2SO_4)	.00	28.29	10.71	5.56	.00	2.85	.00	.00
Calcium chloride ($CaCl_2$)	.00	.00	.00	.00	3.89	.00	.00	.25
Magnesium chloride ($MgCl_2$)	3.98	.00	.00	.00	17.40	9.73	3.88	7.71

Constituents.	6515. Center S. side sec. 20, T. 8 S., R. 23 W.; alkali crust and mulch, 0 to 1 inch.	6520. Center S. side No. 13-40, sec. 36, T. 8 S., R. 23 W.; alkali crust and mulch, 0 to 1 inch.	6516. NW. corner No. 1-40, sec. 26, T. 8 S., R. 24 W.; alkali crust, 0 to 1 inch.	6525. No. 6-40, sec. 9, T. 10 S., R. 24 W.; alkali crust, 0 to ¼ inch.	6526. No. 14-40, sec. 6, T. 10 S., R. 24 W.; alkali crust, 0 to ¼ inch.	6522. N. side sec. 33; alkali crust, 0 to 1 inch.	6519. No. 12-40, sec. 36, T. 8 S., R 24 W.; alkali crust, 0 to ¼ inch.	6523. Center of sec. 17, T. 9 S., R. 23 W.; alkali crust, 0 to 1 inch.
Ions:	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Calcium (Ca)	6.56	8.78	5.70	2.35	0.92	1.55	.87	1.55
Magnesium (Mg)	2.67	3.39	6.76	.45	.28	1.00	.04	.25
Sodium (Na)	26.83	20.81	20.99	28.50	32.70	27.65	37.46	31.49
Potassium (K)	1.22	4.87	2.14	4.21	1.77	4.63	.88	6.50
Sulphuric acid (SO_4)	2.31	1.76	.87	41.82	37.73	20.75	10.64	5.31
Chlorine (Cl)	59.73	59.88	63.09	21.80	26.40	43.94	49.86	53.66
Bicarbonic acid (HCO_3)	.68	.51	.45	.64	.20	.48	.25	1.24
Conventional combinations:								
Calcium sulphate ($CaSO_4$)	3.25	2.50	1.23	7.98	3.14	5.26	2.97	5.28
Magnesium sulphate ($MgSO_4$)	.00	.00	.00	2.23	1.40	4.98	.36	1.27
Potassium chloride (KCl)	2.33	9.28	4.08	8.08	3.39	8.82	1.69	12.39
Sodium chloride (NaCl)	67.50	52.33	52.87	29.65	40.90	60.96	80.72	78.53
Sodium bicarbonate ($NaHCO_3$)	.93	.70	.61	1.15	.27	.66	.34	1.71
Sodium sulphate (Na_2SO_4)	.00	.00	.00	50.91	50.91	19.32	13.92	.82
Calcium chloride ($CaCl_2$)	15.48	21.90	14.70	.00	.00	.00	.00	.00
Magnesium chloride ($MgCl_2$)	10.51	13.29	26.51	.00	.00	.00	.00	.00

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An examination of these analyses shows the alkali in this area to be white alkali, no sodium carbonate being present. In all cases there is an abundance of calcium sulphate ($CaSO_4$), which is seldom if ever found associated with harmful amounts of sodium carbonate (Na_2CO_3). The principal salts present are the chlorides of sodium, calcium, potassium, and magnesium. Only in a few localities are there more of the sulphates than of the chlorides. Sodium chloride (common salt) constitutes on an average nearly 60 per cent of the soluble matter present. When sufficiently concentrated this salt is extremely harmful to plants, 0.60 per cent being sufficient to kill ordinary crops. The other salts present are all harmful when present in sufficient concentration, except the gypsum ($CaSO_4+2H_2O$), which is only slightly soluble in pure water, so that if it alone were present not enough would go into solution to injure plants. On the other hand, when a comparatively strong solution of sodium, magnesium, or potassium chloride or carbonate, or any mixture of them, is brought into the presence of gypsum the latter becomes quite soluble. In this case, however, instead of increasing it decreases the harmful effect of the solution upon plant life. This fact has been demonstrated in the laboratory and has often been observed in the field, although the explanation for it is yet obscure.

It is on the loam soil of the valley, where the heavy soil extends below the level of the ground water, that especial care must be exercised to get rid of the alkali now accumulated and to prevent further accumulation of these salts. This soil is heavy, sticky, and plastic, and is but slowly pervious to water. It is therefore very difficult to remove the salts by leaching. Every available means should be used to make the texture of these soils more open. Stubble should be plowed under, and all the trashy barnyard manure available should be applied. The plowing under of this trash produces two results—is beneficial to alkaline lands in two ways: Not only does it improve the natural drainage of the soil, but it also aids in preventing evaporation, which is a very important consideration in the attempted reclamation of alkali lands.

AGRICULTURAL METHODS.

In that part of the valley situated above the overflow line farming will be comparatively simple. The same crops may be grown and the same methods of cultivation and irrigation used as in other parts of the Territory. Already alfalfa, the chief crop of the Territory, has been grown with reasonable profit. For this part of the valley the usual problems of proper cultivation and methods of application of water in irrigation are the things chiefly to be studied. The soils are mostly sandy, making the maintenance of good tilth a comparatively easy matter. Such soils, however, where the water table is near

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PLATE LVI.

A WELL ESTABLISHED ALFALFA FIELD IN THE YUMA AREA, ARIZONA.

In the foreground is an adobe hole for the watering of cattle.

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enough to permit capillarity to bring water to the surface, there to be evaporated in great quantity, as is the case in this dry, superheated region, if left uncultivated soon become alkaline, even when the water contains only a small amount of soluble matter. Such a condition has already arisen in the soil areas contiguous to the part of the valley subject to annual overflow. The whole valley being underlain by sand, for at least two or three months of the hottest part of the year the ground water of the entire valley is raised by the overflow from the river. Water in wells even back along the mesa is reported as rising and falling with the overflow. From the mesa the land slopes gradually to the overflowed portions, so that only in the lower elevations does the water approach close enough to the surface to cause alarm.

To prevent this accumulation of alkali and remove any excess of alkali now in the soil is a great problem for the farmer of the region. The prevention of further accumulation is all expressed in one short sentence: Prevent the evaporation of water from the surface. If it were well understood that each drop of water carries its little burden of soluble matter (here about 100 parts in 100,000) and that every drop that evaporates leaves behind at the surface of the soil this soluble matter to form the alkali crusts, surely more precaution would be taken to prevent such evaporation. How can evaporation best be prevented? First, by keeping the water table below the reach of capillary action, and second, by shading the surface or maintaining a mulch which will cause a break in the capillarity. The water table may be prevented from rising by using water as sparingly as possible or by proper drainage to carry off the excess. If the crop be one where tillage is possible, much evaporation may be prevented by at all times maintaining a perfect soil mulch, the mulch being renewed from time to time by thorough cultivation. The cultivation should take place as soon as possible after each irrigation, and if water is applied at long intervals the mulch should be renewed between times, for if left uncultivated the soil soon packs and capillary connection is again established. If the crop be one which does not permit of intertillage, as wheat, rye, or alfalfa, then the greatest care should be exercised in leveling to get each portion of the field in condition to be covered by the water in flooding, and in seeding to secure a full stand, which in a short time will effectually shade the surface and retard evaporation. The method of flooding, which is the common practice for alfalfa and small grain, is a great recompense for the inability to cultivate. It can be readily seen that in any system of cultivation and application of water there is of necessity some evaporation from the surface. But when flooding is practiced and the entire surface is covered each time, the accumulation from the evaporation since the last irrigation is washed down into the subsoil, where, if there be movement of the ground water or sub-

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drainage, it enters the current and is carried away. Not so, however, in tilled crops and orchards where furrow irrigation is used. Although the orchard or field be ever so well cultivated, yet there will be places between the furrows and in the rows that are never wet directly from the surface, but only by subirrigation, so that whatever soluble matter is left behind from long evaporation is not carried below, but remains at or near the surface, the accumulation soon becoming great enough to injure the plants. So for all tilled crops in a region liable to become alkaline the obvious remedy is occasional complete leveling of the land and surface flooding. Many shallow-rooted, very sensitive trees, such as the orange and the lemon, throughout southern California and Arizona show signs of disease and are suffering simply because water has been applied for a great many years wholly by the furrow method, with a consequent accumulation of alkali. A flooding of these trees would, in many cases, afford almost immediate relief. Much can be done to avoid such injury in this area by carefully avoiding the mistakes made by these early irrigators.

To recapitulate, the following rules should always be kept in mind: Alkali always follows the water. If water continually evaporates from the surface, then alkali will accumulate. To prevent this keep the water table low, at least 6 feet for the loam soils and 4 feet for sand. When land is to be flooded it should be thoroughly leveled, so that all parts will be covered by the water, else the alkali will accumulate on the high places. Tilled fields and orchards should occasionally receive a thorough flooding to wash down the salt left by unavoidable evaporation.

There are other questions of great importance to be considered when farming is begun in earnest, such as the kinds of crops to be grown and the rotation to be followed so that the soils may retain their great fertility. The Colorado River has often been called the Nile of North America. The sediment carried by both these rivers is very rich in plant food, making it well-nigh impossible to impoverish lands irrigated with their waters. Lands along the Nile have been cropped for centuries, and yet when they receive their full quota of rich sediment they produce crops in abundance. The climate of the Upper Nile region and of this Lower Colorado River country are in many ways similar, so that many of the crops which have thrived for centuries in Egypt would no doubt prove profitable here. Already active steps have been taken by the Department to introduce some of these crops. The farmers of this district should do everything in their power to make these introductions a success, as they may mean the difference between success and failure of the agricultural industry for much of this area.

It is on the overflowed part of the valley that especial care should be taken in beginning cultivation and where particular study should

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decide the kind of crops to be grown after the complicated problem of reclamation is solved. In clearing the land of native vegetation care should be taken not to allow the land to stand without a covering of some kind unless cultivation is begun immediately. (See Pl. LV.)

The first problem here is the control of the overflow water. Until this water is effectually in hand no farming worthy of the name can be done. To control the overflow it will be necessary to construct a dike or levee along the river, to connect with the mesa land below, of such height and strength as to keep out the river. As has been previously stated, the ground water of the valley rises and falls with the river, and some places are now overflowed 6 to 8 feet. The confining of the river would cause it to rise higher in the channel, so that the ground water over the present overflowed part of the valley would have several feet of head, thus bringing it near to or above the surface. This would necessitate the installation of a drainage system, with a pumping plant at the lower end of the valley to lift the water above the levee and back into the river. This leveeing and draining would be expensive, but since the subsoil is usually quite porous the drains need not be close together, and the natural fertility of the soil, together with the advantages of abundant water and almost tropical climate, would certainly make such reclamation a paying investment.

The date palm is generally conceded to be the crop which, by long cultivation in a similar region in Africa, has become peculiarly adapted to the soils and climate of such an area as this. Date palms will thrive in soil having as much as 3 per cent of alkali. Experiments are now being carried on in the Salt River Valley to test the Algerian date palms in Arizona, and the present season some experiments will be made with Egyptian cotton in the Colorado delta. Other crops from parts of the globe with a similar climate should be tried until a new agriculture, consisting of crops which it is impossible to grow in the colder parts of the United States, shall be developed. Such an industry should yield to the farmers a revenue far greater than that now derived from the almost exclusive growing of alfalfa and the raising of stock.

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SOIL SURVEY FROM ARECIBO TO PONCE, PORTO RICO.

By CLARENCE W. DORSEY, LOUIS MESMER, and THOMAS A. CAINE.

LOCATION AND BOUNDARIES OF THE AREA.

The island of Porto Rico is the fourth in size of the Greater Antilles group of the West Indies. Its area is approximately 3,600 square miles, or about four times the land surface of Long Island. Lying between 17° 55′ and 18° 30′ north latitude and 65° 39′ and 67° 11′ west longitude, the island is distant from the most eastern point of Cuba 450 miles and from New York 1,400 miles. Haiti, the nearest island of importance, is 75 miles distant, due west. (See fig. 25.)

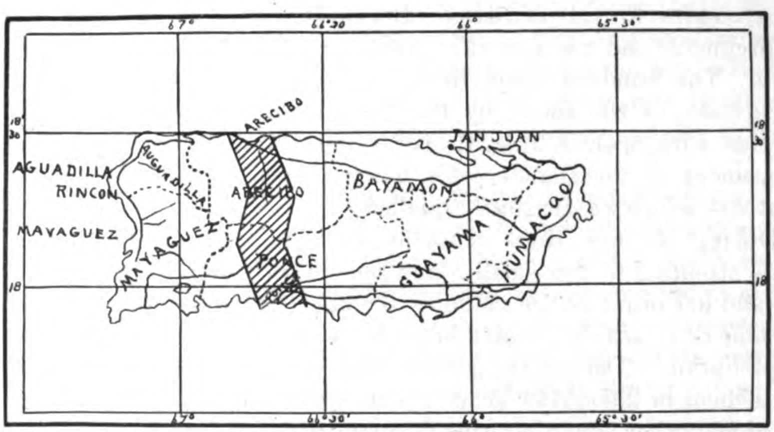

FIG. 25.—Sketch map showing area surveyed in Porto Rico.

The present soil survey covers an area of 211,180 acres, or about 330 square miles, in the western half of the island, comprising a strip 10 miles wide—5 miles on each side of the military road—extending from Arecibo, on the north coast, to Ponce, on the south. As no accurate topographic survey had been made of the area, it was found necessary to precede the soil survey by a traverse party, which was, however, composed of men in the soil-survey party, and the soils were plotted on a base prepared in this way. The traverse work was checked on both coasts with United States Coast and Geodetic Survey maps, with which it was found to agree nicely. It is believed that this insures the reasonable accuracy of the boundaries of the soil areas in the interior of the island.

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The Porto Rican soil survey was undertaken at the request of the Office of Experiment Stations, which through the cooperation of the agricultural experiment station of the island rendered assistance and advice and paid a part of the field expense of the work.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Porto Rico was discovered by Columbus on his second voyage to America (1493), but it was not until 1510 that the first attempt at colonization was made by Spain. In that year Ponce de Leon founded the city of Caparra, soon afterwards abandoned, and in the following year, with more success, San Juan de Bautista, later called Puerto Rico, and now San Juan.

From its discovery to its acquisition by the United States Porto Rico continued a Spanish possession, although attacked many times by foreign nations, especially by the English, and harried by freebooters and pirates. Drake sacked San Juan in 1595, and Abercrombie, in 1797, in what was the most formidable expedition ever planned against the colony up to that time, laid siege to San Juan and the Morro castle for thirteen days. But he found the great stone fortress impregnable and was forced to withdraw his fleet and army of 3,000 men. The hundred years intervening between this attack and the occupation of the island by the United States troops saw no interference with Spanish rule, if we except one single and very feeble movement of the islanders for independence early in the nineteenth century, which was promptly quelled.

During the first three centuries of her dominion Spain paid but little attention to this small island possession, but as one by one Mexico and her other richer colonies revolted and were lost, Porto Rico became of relatively greater importance and was the object of greater exploitation. Data of the growth of population and the extension of settlement in the earlier years are meager. No definite reports of the fiscal and other administrative departments of government were made until toward the end of the eighteenth century. The population was increased to some extent by immigrants from San Domingo and the French settlement in Haiti, driven out by the insurrection of the negroes against the whites, which occurred in 1789 and the years closely following. Settlement was encouraged during a limited period following 1815 by a royal decree granting free land to colonists, the amount being proportioned to the number of slaves owned. These lands were exempted from taxation for a period of ten years, and the settlers were relieved for a like period from the payment of either import duties on agricultural machinery or export duties on the products of their plantations.

In 1765 the population of the island was 44,883; in 1802 it had increased to 163,192, and in 1899 to 953,243. The density of population is to-day seven times greater than that of Cuba, and greater than

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that of any of the States except Massachusetts and Rhode Island. About three-fifths of the population are white, the proportion of whites to negroes, pure or mixed blood, being about the same as in Virginia, and greater than most of the Southern States. There are now in Porto Rico 57 towns with a population of 1,000 or over. Four of these—San Juan (32,048), Ponce (27,952), Mayaguez (15,187), and Arecibo (8,008)—have populations above 8,000. Ponce and Arecibo are situated within the area surveyed.

The population of Porto Rico is largely rural, the percentage of urban population for the different civil departments, according to the last census, ranging from 13 to 29 per cent of the total population. The percentages for the departments of Arecibo and Ponce, within which the area surveyed lies, were 13 and 23 per cent, respectively.

The agricultural development of the island has been based mainly on the production of sugar and coffee, while stock raising has also been an important factor, and tobacco, and more recently fruit, have contributed a considerable part to the revenues received from articles exported.

In 1815 sugar cane was brought into the island from Haiti, where Columbus had introduced it on his second voyage, but only molasses was manufactured until 1548, when the first mill for the production of sugar, to be run by water, was built. In 1581 there were 11 mills in operation whose aggregate production amounted to 15,000 arrobas (375,000 pounds, or 187 tons).

Many fluctuations in the production of sugar have taken place. At one time in the seventeenth century the cultivation of cane was almost entirely displaced by the cultivation of ginger, and a royal decree prohibiting the growing of the latter crop and governmental aid in rebuilding of sugar mills had to be resorted to in order to resuscitate the languishing industry. The wrecking of the mills and the destruction of the crops by hurricanes has now and again almost ruined the industry.

The exportation of sugar reached its maximum in 1879, when 170,000 tons, the product of 553 mills, were shipped from the island. From that point the exports, which may be taken as an index of production, declined to a minimum of 47,000 tons in 1893, whence they have slowly risen to about 90,000 tons in 1899.[a]

This later decline in the production has been due principally to the low price of sugar and the impossibility of manufacturing sugar at a profit with the old methods and old machinery that have been in use in the great majority of Porto Rican mills. Scattered over the island one sees many sugar mills of the old type disused and rapidly going to ruin. To equip a modern mill a capital of from $350,000 to $500,000 is

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[a] See Bulletin on Porto Rico, Bureau of Statistics, Treasury Department.

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needed, an amount so large that few individual planters are in a position to change their mill equipments to meet the new conditions of competition. The tendency is, therefore, toward the centralization of the industry, the establishment of large mills—partly cooperative—and the absorbing of the smaller by the larger plantations.

These few main facts give some idea of the development of the sugar industry in the island at large and apply pertinently to the area surveyed. At present sugar cane is relatively of less importance in the Department of Arecibo, where, according to the latest figures, it occupies 5 per cent of the cultivated area, than in any of the other departments. The proportion in Ponce is three times as great.

Coffee was introduced into the other Antilles from Martinique, where it was first planted in 1720, by M. Declieux, who brought the seed from the Botanical Garden in Paris. It is believed to have been brought into Porto Rico by French refugees from Haiti in the eighteenth century. The production amounted to 728,025 pounds in 1770, and by 1776, through the remission of taxes, the production had nearly doubled. The market at that time was limited to Mediterranean ports, and coffee production did not hold an important place in the agriculture of the island until nearly one hundred years later, when the admission of coffee into the United States gave a great impetus to the industry. In 1850 the production amounted to 11,783,684 pounds, in 1870 to 17,416,762 pounds, and in 1897 to 51,710,997 pounds. The crop of 1898 would have been very large had it not been almost wholly destroyed by the severe hurricane of that year.

Recent statistics place the proportionate acreage of coffee at 36 per cent of the cultivated area of the island. In the Department of Arecibo the crop now normally occupies 50 per cent, and in Ponce 43 per cent, of the cultivated area.

Tobacco is indigenous to the island, but in the earlier years of settlement its cultivation was interdicted, both by papal bulls and royal decrees, the latter issued in 1608. However, its cultivation was permitted by a special law passed in 1614. By this same law the sale of tobacco to a foreigner was prohibited on penalty of death and confiscation of property. Other stringent measures were enacted in 1777 and 1784 which by their very severity defeated their own purpose. In 1775 the crop reached 701,750 pounds. Production was large enough to permit of exportation in 1836 (4,954,200 pounds), but by 1838 had declined to half that amount. The maximum crop was that of 1880, when 12,000,000 pounds were produced. The crop of 1897 reached 6,250,000 pounds.

The tobacco formerly went largely to Cuba, and a prohibitive customs duty in force in that island at present has greatly curtailed the acreage of the crop in Porto Rico in the last two seasons. Tobacco, while the third product of the island of importance in the foreign

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trade, is relatively unimportant as regards the area devoted to its production. It is, however, of great importance, considered in the light of the possibilities of future extension. In the Departments of Arecibo and Ponce but 1 per cent of the cultivated area was devoted to tobacco in 1897.

Grazing of neat cattle and other live stock formed the chief industry of the colonists during the early history of the island, and it is still an essential part of the rural husbandry. Of the subsistence crops plantains, bananas, sweet potatoes, tanier, indian corn, rice, and cocoanuts have played important rôles in the development of the country over which the present soil survey was projected.

CLIMATE.

The area surveyed has a wide range of climatic conditions. While no complete records are available for the area, United States Weather Bureau stations are situated at Arecibo, Utuado, Adjuntas, and Ponce, where records have been kept for the last two or three years. The accompanying table shows the mean annual temperature for Arecibo and the mean annual precipitation for the district about Adjuntas, the other data being fragmentary. From these figures it will be observed that the climate is typically tropical, and that there is but little variation in the temperature from one month to another. Cool trade winds from the northeast lower the temperature considerably, and the island enjoys the reputation of being quite free from tropical diseases and fevers. As Ponce is on the southern coast, which is warmer and drier, it undoubtedly has the highest annual temperature of the entire area. Adjuntas, situated at an elevation of about 2,000 feet, is known as one of the coolest towns on the island. The normal temperature for Arecibo is 76.1° F.

December, January, and February are considered the coolest months, while August, September, and October are the warmest months. The precipitation as shown by the records at Adjuntas is least during February and greatest during April, June, July, August, and October. The rainfall for Adjuntas, as given in the accompanying table, is nearly 100 inches. Adjuntas and Utuado receive the greatest amount of rain because of their situation in the higher altitudes of the northern slope.

As compared with the northern side of the island, the southern side is quite dry, making irrigation necessary for the successful cultivation of most crops.

The moisture-laden trade winds blowing from the northeast pass over this area, causing a higher precipitation on the north side, and especially near the summits of the mountains. It is said that the mountains above Utuado and Adjuntas are frequently enveloped in clouds for months at a time, and that occasionally during the rainy

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season the sun is not seen for weeks. Frosts probably never occur; at least killing frosts are unknown anywhere on the island.

Mean monthly and annual temperature and precipitation, 1900.

Month.	Arecibo.		Utuado.		Adjuntas.		Ponce.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° *F.*	*Inches.*	° *F.*	*Inches.*	° *F.*	*Inches.*	° *F.*	*Inches.*
January	73.4	....	[a] 75.8	....	67.4	2.58	[a] 73.2	....
February	73.0	0.87	....	....	67.5	.63	....	....
March	72.8	1.55	....	0.45	67.9	1.62	[a] 75.5	....
April	75.2	5.38	....	2.09	71.0	12.29	77.2	[b] 2.00
May	77.0	3.16	....	4.25	76.0	9.47	79.1	[b] 7.90
June	78.0	7.43	81.2	8.34	75.0	18.92	[a] 79.5	[b] 6.10
July	78.2	4.84	....	2.47	[a] 75.8	11.06	80.5	[b] 2.90
August	78.4	4.25	....	3.45	79.5	21.42	80.4	3.76
September	78.5	3.59	....	3.37	....	4.61	....	....
October	77.4	4.79	[a] 82.6	....	79.8	10.94	....	....
November	76.6	6.28	80.1	8.11	80.1	2.82	....	....
December	74.9	5.89	74.3	1.08	79.1	1.54	....	....
Year	76.1	....	....	....	....	97.90	....	....

[a] Incomplete. [b] Normals.

PHYSIOGRAPHY AND GEOLOGY.

As the area surveyed passes over the three main physiographic regions of the island, it may be well first to briefly describe the physiography or surface relief of the entire island.

The greater part of the island consists of a series of mountain chains, composed largely of igneous and volcanic rocks, stretching in a general easterly and westerly direction, except in the northeast portion of the island. The mountain region is deeply carved and eroded and consists of a series of "cerros," or knobs, and elongated ridges from which rise numerous sharp peaks. Its altitude varies from less than 1,000 feet to about 4,000 feet.

Surrounding this central mountainous region is an area sloping gently to the sea, composed of coral limestone of considerable thickness. This area is of sedimentary origin and indicates that the whole island has been lifted about 1,000 feet above the sea in recent geologic time. This fringe of limestone is several miles wide in places, and where rock solution has been the most active agent of decay it presents the form of a table-land, but where erosion has been the most active this form has been lost and the surface consists of innumerable conical hills.

Lower down comes the coastal plain, with its low, rounded limestone hills, lagoons and swamps, and rich alluvial lands at the mouths of rivers.

In the area under consideration all these physiographic forms are

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well developed, and so marked are the general characteristics of each that they stand out in bold contrast. The coastal plain in the area surveyed in the Department of Arecibo consists of low, rounded hills, the wide playa plain, and the coast lagoons and swamps. East of the Arecibo River and for a distance west of the city itself are low bars of sand dunes and beach sand. These bars and dunes, usually only a few feet in height, generally rest on a ridge of firmly cemented coral sand and fine gravel. They are covered with a coating of loose, incoherent coral sand, which is drifting southward, driven by the strong trade winds, which almost continually blow from the northeast. The city of Arecibo is built upon one of these low, rounded hills of firmly cemented coral sand; also the light-house and village east of the Arecibo River.

Just back of these dunes are generally found narrow swamps or lagoons, usually covered with thick clumps of mangrove bushes. These swamps are partly marine and partly alluvial in origin. West of Arecibo the swamps are of slight extent, and nowhere do they attain a width of more than one-third of a mile. East of the river the coastal swamps reach greater proportions, as will be seen from an inspection of the map. Certain parts of this swamp have been reclaimed and planted to sugar cane. More extensive reclamations have been planned at various times, but as the question of ownership of such tracts of land has not been definitely settled no considerable operations have been carried out. Much of this land, if properly drained, would make valuable sugar land, but in some localities thorough drainage would be an expensive undertakiug.

The playa plain includes an area of several miles situated on each side of the Arecibo River, with the greater development on the east side of the river. This plain, situated but a few feet above the sea, is remarkably even, with but few changes in elevation. It comprises all the valuable cane land near Arecibo, and probably represents a former estuarine deposit, laid down at a time when the land stood at a lower level than at present. The Arecibo River meanders through this plain, and only in times of the greatest floods, such as that which occurred during the hurricane of August, 1898, does the water cover any considerable portion of the plain. At the time of the hurricane the greater part of this plain was covered with several feet of water. The playa consists almost entirely of fine silt to a depth of several feet, and represents the slow deposition of such material in comparatively shallow, quiet waters. (See Pl. LVII.)

South of the alluvial lands near Arecibo are low, dome-shaped hills. Some of the lower ones have been nearly buried by the alluvial deposits of the river. Others rise symmetrically to a height of 100 feet or more. The rock of which these hills are formed is a soft white limestone that seems to weather uniformly, leaving few, if any, projecting

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ledges. On top of the hills the soil is very shallow, while farther down it becomes deeper and richer. The thick mat of grass which usually covers these hills, together with the loose, porous rock below, prevents washing. West of Arecibo these hills extend down to the coast and are more numerous though not so symmetrical in form. From above they have the appearance of a rolling plateau. Prominent groups of these hills lie to the southeast of Arecibo, 4 miles directly south of the city in a great bend of the river and 1½ miles southwest of the city. (See Pl. LVIII.)

Inland from the area of low, rounded limestone hills in the vicinity of Arecibo, and extending south for about 8 miles, is a large area of limestone, which, because of its greater elevation, rough, angular topography, the decided change in vegetation, a thick growth of trees and bushes, and the many bare rocks of chalky whiteness, stands out in marked contrast to the region to the north. The elevation of this material varies from about 200 feet near Arecibo to about 1,000 feet, where it rests as a mere capping upon igneous and volcanic rock along the Limon and Caiguantes rivers. These rivers seem to have adjusted themselves very largely to the old shore line, probably because it was a line of weakness, so that at present there is a noticeable valley in the vicinity of the line of contact. Where these rivers enter the Rio Grande de Arecibo they have cut deep gorges into the igneous and volcanic rock below, leaving an isolated capping of limestone at the junction of the Arecibo and Alonso rivers.

Along the northern border the hills are separated into parallel chains, frequently inclosing small, level valleys, but farther south the hills are more closely packed together and become a series of almost impassable barrancas or rock-walled canyons and pits. The steep-sided depressions show, on a tremendous scale, the enormous extent to which rock solution takes place under tropical conditions. They represent an almost endless series of great limestone sinks or basins formed by the dissolution of the softer layers of limestone by rain water. The water causes great underground cavities to be formed, the roofs of which finally break through and leave the perpendicular rock walls exposed. Standing on any of these hills capped with the harder stratum of limestone, the enormous size of the sink holes is at once realized. They are great basins with bare, perpendicular rock walls, frequently 100 feet deep, and sometimes reaching a depth of 200 feet. These basinlike depressions occasionally include small swampy spots, or a great spring may break forth in one side only to disappear in the opposite side. Some contain a few acres of fertile land. Frequently the streams and even large rivers that traverse this limestone country disappear altogether for considerable distances. In one instance the outlet at the bottom of one of these basins had become obstructed, and a small lake had been formed, in the midst of which were still growing cocoa palms and bread-fruit trees, while the empty buildings in the

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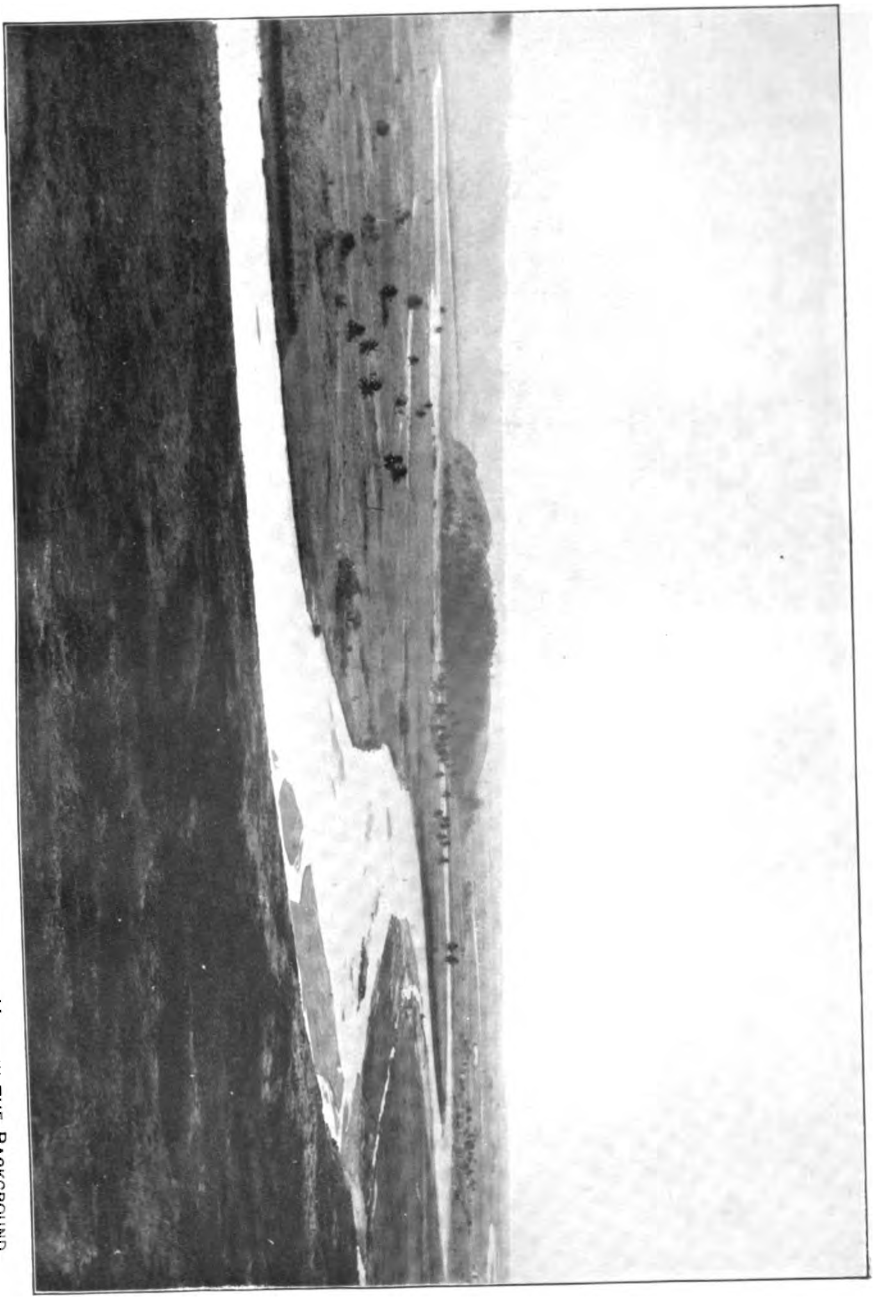

THE ALLUVIAL PLAIN NEAR ARECIBO, PORTO RICO, USED FOR SUGAR LANDS, WITH THE LIMESTONE HILLS IN THE BACKGROUND.

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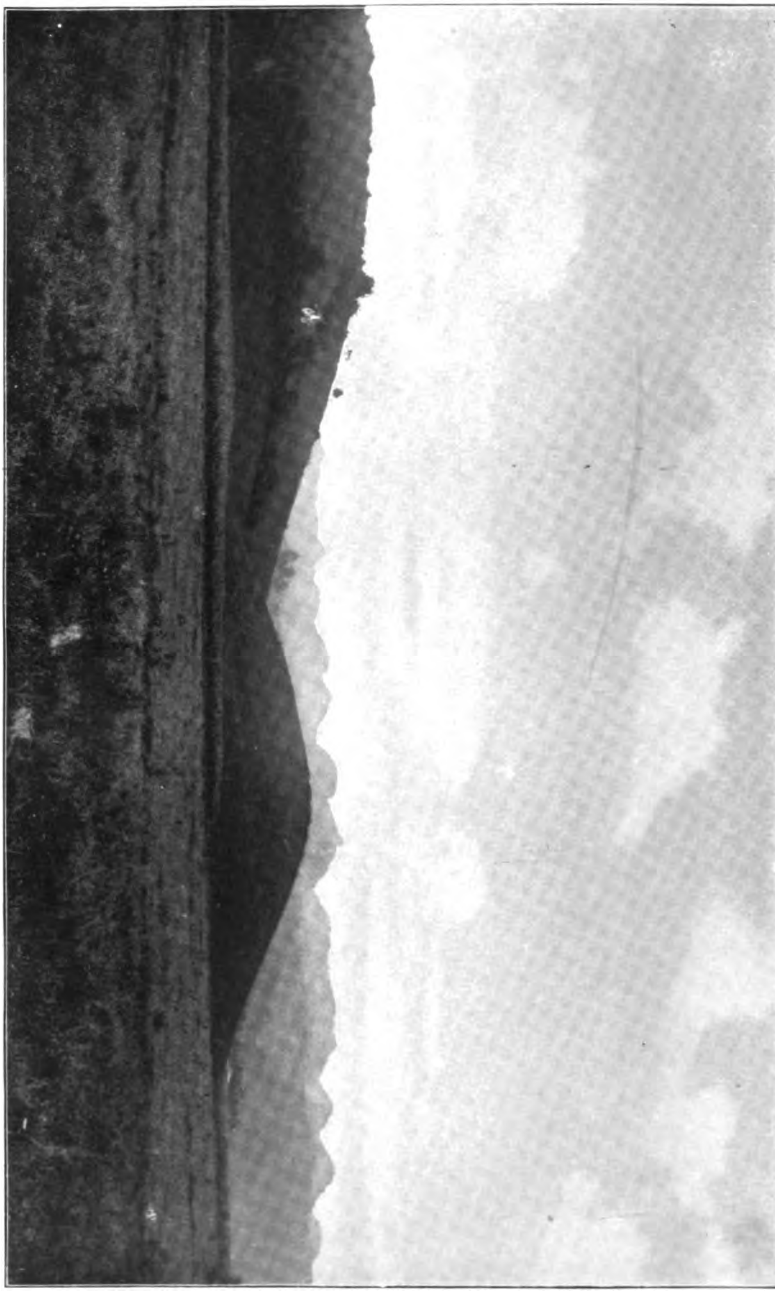

A VIEW FROM THE ALLUVIAL PLAINS, SHOWING THE LOW, ROUNDED HILLS OF THE ARECIBO LOAM AND THE LIMESTONE HILLS OF THE TANAMA STONY LOAM, PORTO RICO.

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center, still in a good state of preservation, showed that the inundation had occurred within the last few years. The drainage of this region is mainly subterranean, and only two large rivers traverse it, the Arecibo and the Tanama, which carry a large part of the waters from the interior of the island. Both of these rivers flow in deeply cut canyons.

This broken table-land slopes gradually to the southward and its central region is most inaccessible and difficult to cross. Away from the military road only narrow trails traverse this country, and the question of transporting the products which may be grown in this region will always be a serious one. The trails, stony and rough, wind in and about the narrow ravines and frequently one has to cross five or six divides from 200 to 500 feet high in going a mile. Over such trails the native goes barefooted, either carrying his product to market on his shoulders or on the back of his little pack horse. Still, many people find a habitation in the limits of this hilly region, for the stony soils are comparatively fertile, although almost inaccessible and difficult to till. The rocks comprising this table-land consist of layers of hard and soft limestone of Miocene age. Along their margin these rocks contain many coral heads, often several feet in diameter.

On the south side of the island this limestone region has a very different appearance. The valley between it and the inner volcanic regions is much more distinct, as for example at Penuelas, but there is no sign of table-land and there are no pits or sinks. There are few trails and almost no houses. The soils are very shallow and, owing to the arid conditions that exist there, they are at present almost worthless except for pasturage during the wet season.

In point of area the central or igneous and volcanic region is the most important, as it represents more than half the area surveyed. This picturesque region, which is enormously eroded, slopes toward the north. In the valley at Utuado the altitude is about 600 feet, while about 10 miles south, above Adjuntas, where the military road crosses the divide, the altitude is about 2,400 feet, according to barometric readings by Mr. Herbert M. Wilson.[a] West of this point, on the border of the area surveyed, Mount Guilarte, the second highest peak on the island, rises over 1,000 feet higher. South of the divide the descent is very rapid, the distance to the seacoast being only 15 miles in an air line from Mount Guilarte.

The divide is but 11 miles from Ponce, while it is about 25 miles from Arecibo. The position of the divide, so far to the south side of the island, may be accounted for by the fact that the trade winds, which blow continually from the northeast, are robbed of their moisture before or while passing over the divide, and therefore there is a

[a] Water resources of Porto Rico (1900).

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greater rainfall on the north side of the island. The heavier rainfall has produced greater erosion and slowly shifted the divide southward. On the north this ridge slopes gently, with numerous knobs and elongated ridges, to the valley lying at the junction of the Alonso and Arecibo rivers. Valleys similar to this are frequently called "parting valleys," for usually at the junction of the limestone table-land and the central-mountain region a well-defined valley is observed. It is along the junction of these two physiographic regions, also, that the main drainage rivers have developed the lateral tributaries which have formed them.

Throughout the central mountain region there are many rapid streams. The amount of rainfall and conditions of temperature are such that the rate of erosion is tremendous. At Utuado the erosion forms are very beautiful, and an accurate relief model of the valley and surrounding mountain slopes would appear almost as if constructed after someone's fancy. The rocks in this vicinity are a coarser-grained granite that has weathered more rapidly than the surrounding country, the valley being the result. The rate of erosion of this rock at the lower elevations has been greater than the rate of weathering, as shown by the sandy character of the soils, which are of little agricultural value. On the higher elevations, where weathering has been more rapid than erosion, the characteristic soils are deep reddish clay loams and tenacious red clays. Such soils are best for coffee, and throughout this region coffee plantations may be seen on every hand.

Fine examples of the rocks of the central mountain region may be seen along the military road from Arecibo to Ponce, where they are used for road ballast. Many volcanic conglomerates, containing bowlders several feet in diameter, were noticed, as well as extensive areas of volcanic tufa. South of the divide, the dividing ridge being only 11 miles distant in an air line from Ponce, the slope is much steeper, and the streams are correspondingly much smaller and in the upper part of their valleys are rapidly eroding their channels. Owing to the semiarid conditions of this region irrigation is necessary, and the streams either dry up or become nearly lost in the sands and gravel in their lower reaches. On the southern portion of the island the limestone foothill region, while not so prominent as on the northern slope, forms a considerable table-land, similar in many respects to that found on the northern side of the island, but not so broken and dissected, nor is it situated at so great an elevation above the level of the sea. There also occurs an area of low, rounded hills, but they lack the symmetry of the hills around Arecibo. South of the limestone table-land, in the vicinity of Ponce, a considerable playa plain has been developed at the mouth of the Portugues River. This plain forms the sugar lands of the south coast and is quite similar in many respects to that which

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occurs in the vicinity of Arecibo, the chief distinction being the more sandy texture of the soil.

Four and one-half miles southwest of Ponce there is a large lagoon much like those on the north coast. It is quite deep and is protected from the sea only by a bar of sand. Along the coast to the south and east of Ponce there are some areas of low-lying alkali land. The abundance of marine shells in this land and in the subsoil of much of the land in the vicinity of Ponce would indicate that the whole plain was built up by deposits laid down in shallow salt water, just as they are now being laid down in the large lagoon just mentioned.

SOILS.

As the present survey includes a strip passing through all the geological regions and having all the various climatic conditions of the island, it is thought that the soils mapped include nearly all of the important types of the island. They embrace those derived from the slight superficial weathering of coral reefs and sands, from the deep weathering of hard, igneous trap rocks, and from the accumulation of alluvial deposits along the Arecibo and other rivers. The appended table shows the approximate areas of the different soil types.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Tanama stony loam	41,680	19.7	Ponce sandy loam	6,550	3.1
Adjuntas clay	29,890	14.2	Penuelas adobe	6,680	3.2
Utuado sandy loam	25,100	11.8	Portugues adobe	4,010	1.9
Arecibo loam	17,700	8.4	Arecibo sandy loam	2,690	1.3
Pastillo loam	16,040	7.6	Coral sand	2,620	1.2
Portugues stony loam	15,600	7.4	Ponce loam	2,480	1.2
Alonso clay	13,690	6.5	Vivi sandy loam	1,060	.5
Arecibo silt loam	8,960	4.2	Riverwash	970	.5
Utuado loam	7,880	3.7	Total	211,180	....
Arecibo sand	7,580	3.6			

CORAL SAND.

This type consists of coral and shells ground up by the action of the waves and mixed with a small amount of quartz sand brought down by the rivers and driven inland by the winds. On the south side of the island this sand covers several square miles. The areas are low lying, and attain their greatest elevation (8 or 10 feet) within 75 yards of the coast, sloping gradually inland from this point. On the north side the areas of this soil are much smaller. The sand here has drifted up in the form of dunes, beneath which cemented coral sands were found in several places.

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On account of the loose, incoherent nature of this soil it does not contain alkali except in the low-lying places on the south coast, where the water table comes close to the surface.

Several areas of this soil have been planted to cocoanut trees, which are quite resistant to salty conditions of soil. Though in some places the roots of the trees are even washed by the sea, the trees grow fast and begin to fruit in five years. This type is one of the best for cocoanut plantations, and of but little use for anything else in a commercial sense. In a few places fishermen have cleared small areas of Coral sand within 100 yards of the sea and planted them in plantains, bananas, and sweet potatoes for home consumption. The latter were said to do fairly well in favorable seasons. The land is valued at less than a tenth of the value of the sugar-cane lands.

The following table gives the mechanical analyses of the Coral sand:

Mechanical analyses of Coral sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6499	1 mile E. of lighthouse at Arecibo.	Coral sand, 0 to 36 inches.	12.90	1.53	40.10	45.36	9.64	0.75	0.59	2.45
6588	3 miles SE. of Ponce.	Drifted incoherent sand, 0 to 36 inches.	1.02	2.98	16.74	27.50	39.70	5.34	2.96	4.14
6586	3 miles SW. of Ponce.	Coral sand, 0 to 24 inches.	.86	3.60	22.80	25.00	26.40	7.90	7.60	6.46
6587	Subsoil of 6586....	Coral sand, 24 to 36 inches.	.65	3.60	20.16	22.20	26.10	8.70	8.60	10.44

ARECIBO SAND.

Arecibo sand consists of medium-grade sand having a depth of at least 3 feet, with little or no difference in character or in appearance between the soil and subsoil. It is loose and incoherent and easily cultivated, but this open character makes crops planted on it very liable to damage from drought.

The Arecibo sand varies considerably in color, most often being red or white, frequently occurring in shades of brown, yellow, gray, and even black. The gray and black sands are usually closely associated with the white, and undoubtedly owe their color to a mixture of white with a greater or less quantity of thoroughly decomposed organic remains. The red sand possesses a soft feel and consists of rounded grains of coral, the soil and subsoil being the same. The brown and yellow sands are similar in composition and are mixtures and varia-

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tions of the red and white sands. The red soil is usually considered better than the other colors of this type.

The largest areas of Arecibo sand are situated southwest and west of Arecibo. Small patches are also found southeast of the city and a few others in the limestone valleys to the southward. The only area of importance consisting of white sand lies north of the Lares road, 3 miles west of Arecibo. It is made up principally of pure quartz grains, and it is for the most part devoid of vegetation. These soils are either areas of wind-blown sand which has drifted inland from the seacoast or, in some cases, relics of former beaches, constructed at a time when the sea stood relatively much higher than it does at present.

In the small inclosed valleys occupied by this formation the surface is comparatively level, but with some gentle undulations, while to the west and southwest of Arecibo the sand occurs as a covering, a few feet in depth, over rolling hills and valleys underlain by whitish limestone.

Many different crops are grown on these soils, with varying results. Small areas of gondules, sweet potatoes, corn, beans, cassava, and tobacco were observed. A small amount of fruit is also grown, consisting of cocoanuts, bananas, plantains, papaya or papaw, pineapples, etc. The red sand may be adapted to orange culture, although as yet no attempt has been made to grow this fruit on a commercial scale. To the west of Arecibo this soil produces fair crops of Guinea grass.

The brown and yellow sands are used for much the same crops as the red sand. In general the Arecibo sand, with proper fertilization, might produce good crops of pineapples, for it closely resembles—especially in the white phase—the famous pineapple lands of southern Florida; but as yet very little attempt has been made to grow this fruit.

The following table contains the mechanical analyses of samples of the red and gray sands:

Mechanical analyses of Arecibo sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6485	3¼ miles SW. of Arecibo.	Dark medium sand, 0 to 36 inches.	0.53	0.20	14.73	48.86	27.93	3.92	2.66	0.74
6483	1 mile SW. of Arecibo.	Red coral and quartz sand, 0 to 12 inches.	.82	.00	10.31	32.75	43.85	8.22	3.84	1.85
6484	Subsoil of 6483....	Red coral and quartz sand, 12 to 36 inches.	.32	Tr.	8.29	26.66	48.53	8.27	4.22	3.63

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RIVERWASH.

The Riverwash generally consists of a coarse grade of sand, but often it is mixed with varying amounts of coarse and fine gravel. There is little difference between the soil and the subsoil.

The only areas of this soil type occur along the river in the vicinity of Arecibo.

The soil is derived from the deposition of sediment by the river at times of flood, and is liable to overflow during heavy rains at almost any season of the year. For this reason it is not of much agricultural value. Very little attempt is made to cultivate it, and it is covered with a sparse growth of grass, which affords some pasturage.

ARECIBO SILT LOAM.

The Arecibo silt loam, which is one of the most important agricultural soils of the area, consists of a heavy, rich brown silty loam, having a depth of at least 3 feet, and in many cases a depth exceeding 10 feet or even 15 feet. Little difference can be detected between the soil and subsoil to a depth of 36 inches, except that in the lower depths it is usually of a slightly lighter color. When in a moist condition it is of a dark brown, but the surface, after a period of several weeks without rain, becomes decidedly lighter in color. In some localities occasional small bands of coarse sand are found, rarely exceeding a few inches in thickness, and occasionally scattered pebbles are seen on the surface. Along the Arecibo River there are in places shallow deposits of fine or even medium sand, never of sufficient depth to impair the soil for the growing of sugar cane.

The Arecibo silt loam is found south of Arecibo on both sides of the river, occupying the greater part of the plains region of the north coast and extending on the west side to the foot of the limestone hills and on the east side merging into the areas of swamp land or reaching back to the foot of the rounded and sometimes to the angular limestone hills.

This soil has generally a very level, flat surface, but at times this gives way to gently rolling topography. There are a few low terraces, but it is doubtful if in the entire area an elevation greater than 30 feet is anywhere attained.

The Arecibo silt loam is rarely overflowed, except at the times of severest hurricanes. During the hurricane of August, 1898, a large portion of the area was covered with water to a depth of several feet, and a small village located within it was swept away. When the river overflows this land and then gradually recedes there is a decidedly beneficial effect, but in periods of such high water as that of 1898 large tracts of land are completely ruined by the deposit of coarse sand, which often accumulates to a thickness of several feet. On account of the small quantity of clay in this soil it drains readily for a

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heavy loam, although it is necessary to have open ditches at short intervals to carry off the surplus water during times of heavy rainfall. During the wet season these ditches become filled, and the soil is so thoroughly saturated that even slight showers bring the water table near the surface.

The Arecibo silt loam has been formed by the slow accumulations of sediments carried down from the interior mountain region by the river and deposited in comparatively quiet, shallow waters, when the land was depressed below sea level. The soil is the result of the superficial weathering of this extensive deposit of silt, mixed with the vegetable matter that has accumulated from year to year from the growing of sugar cane.

There is a phase of this soil occurring on the south side of the island which consists of about 36 inches of a dark gray silt loam. The areas in this part of the island have been formed in the same way as the more typical areas, but they are lower lying and are apt to be salty and unfit for the cultivation of sugar cane. In a few instances, too, the subsoil was noticed to be slightly heavier than in the typical section. These areas are covered with mangroves and other salt-resisting trees and by coarse salt-marsh grasses and are used for pasture. Drainage and the reclamation from present alkali conditions, and in some cases the construction of a dike along the sea front to keep out the sea water at times of severe storms, would convert these areas into valuable sugar-cane lands.

The Arecibo silt loam is the most valuable soil in the unirrigated district for the production of sugar, to which crop it is almost exclusively devoted, and the sugar industry that has developed on it during the last three hundred years is considered one of the most important on the island. The yield per acre ranges from 30 to 60 tons, but the average is perhaps 40 tons. This yield is equaled only on the Ponce loam, which is an irrigated type, the cane from which has a higher sugar content.

Tobacco is grown to a limited extent on the more sandy portions of this soil along the upper course of the river. The quality of the leaf is said to be very good, though not equal to that produced on the Vivi sandy loam. A yield of 800 pounds per acre is considered high, and the average yield does not far exceed 600 pounds per acre.

Plantains and bananas do very well on this soil, but all crops are of minor importance at present in comparison with the great staple, sugar cane.

Records show that sugar cane has been grown on some of this land for more than three hundred years; and though the yields have decreased, it is said that most of it is in excellent condition and seldom needs "resting," the method of recuperating the soils followed on the island.

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This land commands a high price on account of the large yield it produces, and practically none of it is for sale, as all of the large planters endeavor when possible to increase their own holdings.

The silty character of this soil can readily be seen from the following mechanical analyses:

Mechanical analyses of Arecibo silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6575	2¼ miles W. ¾ mile S. of Ponce.	Light gray silty loam, 0 to 14 inches.	2.45	0.26	0.60	0.50	1.76	9.00	73.24	13.24
6475	2 miles S. of lighthouse at Arecibo.	Rich dark-brown silty loam, 0 to 12 inches.	1.98	.39	.55	.55	10.81	10.81	53.06	24.07
6577	¼ mile E. of Port Ponce.	Dark silty loam, 0 to 36 inches.	1.93	.56	.80	1.70	12.62	9.60	44.76	29.72
6477	4 miles S. of Arecibo.	Rich dark silty loam, 0 to 12 inches.	2.31	.69	2.34	1.79	6.30	10.05	48.62	29.87
6478	Subsoil of 6477......	Rich dark silty loam, 12 to 36 inches.	1.15	.95	2.46	1.83	11.00	10.95	45.58	26.67
6476	Subsoil of 6475......	.....do..............	1.13	.31	.79	.46	4.03	7.27	55.28	31.06
6576	Subsoil of 6575......	Dark loam, 14 to 36 inches.	.24	.60	.54	.40	1.96	5.90	55.68	34.32

ARECIBO SANDY LOAM.

The Arecibo sandy loam consists of a heavy red sandy loam with a depth of 10 inches, underlain to a depth of 36 inches by a clay loam that is rather tenacious and yet contains a considerable amount of medium-grade sand. When cultivated it appears rather loamy on the surface, but when it has lain idle for some time and is covered with a growth of grass it becomes hard and baked, giving one the impression of a much heavier soil.

It occupies some of the valleys occurring among the outlying limestone hills. These valleys are level or gently rolling, with elevations ranging from 30 to 100 feet above sea level, and are nearly all surrounded by hills possessing soils of a decidedly different character. On account of the sandy nature of the soil it is naturally well drained. The Arecibo sandy loam has probably been derived from the windblown or beach sand mixed with the residual products of the surrounding limestone hills.

Usually the areas of this soil are settled by the poorer classes of people and used to a limited extent for growing truck, fruit, and other

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minor crops, such as beans, corn, sweet potatoes, and gondules. Some tobacco is at present grown, but it does not compare in quality with that grown on the alluvial soils in the mountain districts. In the area east of the river, in the vicinity of Santa Ana, some light crops of sugar cane were observed. This soil is much better adapted to pasture, fruits, principally plantains, bananas, cocoanuts, and garden and truck crops than to such crops as cane and tobacco.

The following table contains the mechanical analyses of a typical sample of the soil and subsoil of this type:

Mechanical analyses of Arecibo sandy loam

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6473	4 miles SW. of Arecibo.	Red sandy loam, 0 to 12 inches.	0.46	0.00	4.51	18.39	50.88	6.19	6.39	13.83
6474	Subsoil of 6473......	Stiff sandy clay loam, 12 to 36 inches.	.22	.43	3.66	14.13	41.92	5.80	8.54	25.24

ARECIBO LOAM.

The Arecibo loam consists of a black, waxy, tenacious loam to a depth of from 6 to 12 inches, depending somewhat on the character of the surface where the soil is formed. East of Arecibo, near the ocean shore, this black loam has a depth of at least 12 inches, but on the rounded limestone hills as well as in the large area south of Esperanza the soils are shallower and contain a large number of fragments of the parent limestone. The subsoil is a tenacious yellow loam, which in its lower depths becomes more sandy and contains increasing amounts of loose limestone fragments. In the large area south of Esperanza the subsoil passes at about an average depth of 18 inches into a rotten mass of limestone fragments. In the large area lying along the coast west of Arecibo the soil is shallow, underlain by broken limestone, and with fragments of the parent rock scattered thickly on the surface. The area of this soil found east of the Arecibo River, which is probably in a better state of cultivation and of greater agricultural value than any of the others, has a level or gently rolling surface. West of Arecibo the surface is also rolling, and the elevation ranges from 50 to 150 feet above sea level. South of Esperanza and in a similar area east of the Arecibo River the surface is rough and broken and elevated several hundred feet above the sea. In these latter areas

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the surface is so rough and irregular that the soil can not be utilized to any great extent in the cultivation of the ordinary crops.

From the tenacious character of the material forming this soil a swampy condition is found wherever the surface is not hilly or uneven. East of the Arecibo River, near the shore, many small swamps occupy the slight depressions, and somewhat similar occurrences are met with along the trails in the rough broken areas farther south, which during the wet season become well-nigh impassable.

Near the seacoast this soil has been derived from a soft gray limestone of comparatively recent geologic age. Farther north, in the limestone hill country, it is derived from the chalky white limestone of Miocene age. The latter is frequently spoken of as coral limestone on account of the great number of coral heads found in it.

This soil type is spoken of as "fat land." It is well adapted to pasturage, and in all areas, except where the hills are rough and rocky, is always covered with a thick mat of rich, green grass. A small amount of tobacco is grown on this soil. No attempt, however, at growing tobacco on a large scale, has been made, and it remains to be seen whether extensive tobacco growing can be profitably carried on. Fruits do fairly well, and in the more hilly portions, where the soil is deep, a few orange trees were in fair condition. Where the soil is shallow and rests on solid rock the growing of oranges on a commercial scale should not be attempted. Bananas, plaintains, and coffee, together with gondules, sweet potatoes, and the minor produce crops, are raised to a considerable extent, but always in small patches and with never any attempt at cultivation on a large scale.

The mechanical analyses of representative samples of this soil type are given below:

Mechanical analyses of Arecibo loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6471	3 miles W. of Arecibo.	Dark loam, 0 to 8 inches.	4.98	6.88	10.92	11.14	20.09	11.01	26.24	12.94
6469	1¼ miles E. of lighthouse at Arecibo.	Black, heavy, waxy loam, 0 to 18 inches.	2.33	1.65	9.50	8.53	20.50	9.46	24.86	24.46
6472	Subsoil of 6471....	Yellow loam, 8 to 18 inches.	3.29	6.66	9.13	9.73	17.72	10.22	31.19	14.53
6470	Subsoil of 6469....	Stiff yellow clay loam, 18 to 36 inches.	.29	1.39	8.09	8.45	17.98	5.92	19.85	37.42

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ALONSO CLAY.

The Alonso clay consists of a dark, purplish clay loam, having a depth of from 8 to 36 inches and containing a varying amount of pebbles and sometimes large bowlders. Where the soil is deepest there is a tendency to become more clayey with depth. The subsoil is a heavy tenacious loam of the same color as the soil, resting on a purplish igneous rock of the character commonly called trap rock. In some areas the underlying rock comes to within 15 inches of the surface. The soil has a tendency to form clods when cultivated and to bake upon drying.

Three different areas of this type occur within the limits of the survey. The largest lies along the Limon and Arecibo rivers, the next in extent about 10 miles southeast of Adjuntas, and the third about 4 miles to the southwest of that city.

The Alonso clay is a residual soil derived from the disintegration and decomposition of a dark, purple-colored igneous rock. Fragments of this rock are often found in the soil and subsoil. Frequently these fragments occur as bowlders. These are of the interesting form known to geologists as "bowlders of disintegration," which are believed to be formed from solid blocks of rock by the process of weathering in concentric rings.

There is a wide difference in the agricultural value of the different areas of this soil. The area along the Limon and Arecibo rivers is at present used mainly for pasturage, while the area between Adjuntas and Ponce is found upon steep slopes and is shallow, and with the scanty rainfall is of little value. In a few favored places bananas, plantains, and coffee are produced. The smallest area, that lying southwest of Adjuntas, is the most important agriculturally. The soil is deep and fertile. A large part of the area is in coffee and the trees appear to be healthy and vigorous. The yield reaches 400 pounds of dried coffee per acre, which is not exceeded by any soil type in the area and is equaled only by the Adjuntas clay. Orange trees of large size are also seen, and these are for the most part free from diseases or scale. With the exception of some orange trees on the Adjuntas clay, those on this soil were the best seen in the area. Bananas and plantains are also important crops on this soil. The yield ranges from 50 to 200 bunches per acre, but the bunches are not so large as on the lowlands. The soil of the large area on the Limon and Arecibo rivers appeared very similar to the soil of the tobacco lands of Cayey, and while no attempt to grow tobacco has been made it would seem that the soil is well adapted to that crop.

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The following table gives the mechanical analyses of the soil and subsoil of this soil type:

Mechanical analyses of Alonso clay.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6479	Near junction of Alonso and Arecibo rivers.	Dark heavy loam, 0 to 8 inches.	3.64	4.55	8.11	8.63	17.90	19.05	18.68	22.34
6560	6 miles N. 1 mile W. of Ponce.	Loam, 0 to 28 inches.	1.55	5.78	3.20	2.62	8.66	10.94	35.22	33.30
6481	12 miles S. of Arecibo on Caretera.	Dark heavy loam, 0 to 8 inches.	2.73	.34	3.66	3.98	14.46	10.35	31.78	35.41
6559	6¼ miles N. 2 miles W. of Ponce.	Dark loam, 0 to 14 inches.	1.77	3.10	3.34	1.84	5.14	6.40	38.40	40.86
6558	3 miles SW. of Adjuntas.	Dark loam..........	1.93	.26	1.08	1.14	5.40	8.72	30.74	51.90
6482	Subsoil of 6481......	Dark clay loam, 8 to 36 inches.	.98	.32	2.02	2.79	13.13	7.11	41.35	33.16
6480	Subsoil of 6479......	Dark clay loam, 8 to 30 inches.	1.67	.30	1.72	1.19	4.37	5.76	32.52	53.92

UTUADO LOAM.

The Utuado loam consists of a mellow dark-brown or yellow loam, having an average depth of 8 inches. The soil is generally free from stones and is underlain by loamy subsoil, yellow in color and differing slightly in texture from the surface soil.

The type occupies the low, rounded slopes along the Arecibo River and the rolling, mountainous land a short distance south of Utuado. It ranges in elevation from 100 to 1,200 feet above sea level. The soil is residual, having been derived from the slow decomposition of volcanic and igneous rocks.

The greater portion of this soil is used as pasture land, for which it serves fairly well. In some favored places coffee is grown, and the trees were apparently in a healthy condition. On the protected slopes and under proper condition of shade the cultivation of this crop might be profitably carried on, for the soil is deep and loamy and easily penetrated by roots.

The mechanical analyses of the soil and subsoil of this type are given below.

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Mechanical analyses of Utuado loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6491	8¼ miles N. of Utuado.	Dark-brown loam, 0 to 7 inches.	2.47	1.73	4.77	4.55	16.19	10.62	27.87	33.63
6492	Subsoil of 6491	Light-yellow loam, 7 to 36 inches.	.58	1.08	3.14	5.89	20.04	9.78	29.76	30.21

UTUADO SANDY LOAM.

The Utuado sandy loam is a coarse sandy loam of a grayish-yellow color, grading into a grayish sandy loam. This gradually passes into the coarser material of the underlying granite and other rocks from which it is derived.

But one body of this soil is found in the area surveyed, and this occurs in the mountainous region about Utuado. The town is situated in the northwestern part of this tract, which stretches about 5 miles south and east and passes beyond the limits of the survey.

The surface of the Utuado sandy loam consists of furrowed and gullied hills and mountains. These have an elevation ranging up to 200 feet above the intervening V-shaped valleys. In few of the soils mapped in this survey has erosion been carried on to so great an extent as is seen in this formation. When the sun is shining on the mountain slopes in such a manner as to accent their eroded character, they are seen to consist of almost an endless series of narrow necks and tongues, which rise to higher necks and tongues until the main dividing ridge is reached. These connecting necks are very narrow, and the intervening slopes are in places inclined at an angle of more than 50°. The trails which cross the ridges follow these necks of land, and in many cases so narrow are they that the road must be propped up by posts and small tree trunks to prevent its being washed away by the heavy, dashing rains.

On account of the steepness of the slopes these soils are comparatively dry, even in periods of excessive rainfall. In fact, the drainage is so thorough and so rapid that a short period of drought is liable to injure the crops. At the time of the survey crops of beans, corn, and sweet potatoes were suffering for rain, although but two weeks had elapsed since the soil had been thoroughly drenched.

This soil is residual, being derived from an underlying coarse-grained gray granite and similar igneous rocks. So rapid is the erosion that the surface soil does not accumulate and become thoroughly

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decomposed; hence it bears a close resemblance to the rocks from which it is derived. The sand which forms the greater part of this soil is coarse and angular, being made up largely of quartz grains and undecomposed feldspar.

The Utuado sandy loam has little natural fertility, which is soon exhausted by the present methods of farming. A few coffee plantations lie in the area, and the trees in favored locations appear to be thrifty, but on account of its shallowness and its coarse, sandy texture this soil type is not well suited to coffee culture. Sweet potatoes, beans, corn, and other minor subsistence crops are grown in the area, but not to a great extent. In some places these crops are seen growing on slopes of an angle of inclination exceeding 50°, but such locations are too dry to produce good crops, aside from the difficulty of cultivation and the damage from soil washing and landslides.

The area of this soil has for some time been deforested and is now grown up with a coarse grass, closely resembling the broom sedge commonly found in the Southern Atlantic States. On account of the steepness of the slopes and the rapid rate at which erosion takes place this soil should not be cultivated to any great extent to crops that expose the soil to the heavy rains of the wet season. It would seem that if systematic forestry were introduced much of the area which is now idle waste land might be converted into valuable timber land.

The following table shows the sandy nature of these soils:

Mechanical analyses of Utuado sandy loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6493	2 miles W. of Utuado.	Coarse sandy loam, 0 to 7 inches.	0.74	19.96	19.52	9.43	14.47	9.43	19.18	8.47
6494	Subsoil of 6493....	Coarse sandy loam, 7 to 24 inches.	.25	18.32	20.88	9.49	15.41	11.44	16.72	8.24

VIVI SANDY LOAM.

The Vivi sandy loam consists of a friable brown sandy loam, having an average depth of 10 inches and underlain by a darker-colored sandy loam of a peculiar soft texture. This soil resembles in a way the Utuado sandy loam, being made up of much the same character of material, reworked and ground finer by water action. In some areas a slight variation in texture occurs, the soil losing its loamy character

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and becoming a fine, mellow sand. In other areas the subsoil is slightly heavier than in the typical sections.

This type is found only to a limited extent. The largest and most important area lies along the Arecibo River west of Utuado, while smaller scattered areas occur in small valleys to the southwest of that town. The latter areas are usually surrounded by mountains that rise to a height of 1,000 feet above sea level. The position of this type makes it subject to occasional overflow during the rainy season, and loss of crops sometimes occurs from this cause. The surface is usually level, although there were noticed some well-defined terraces a few feet high sloping up toward the mountains. The soil has been formed by wash from the hillsides and by the deposition of sediment by the streams along which it occurs.

This soil type is more fertile and possesses a much higher agricultural value than the Utuado sandy loam. It is used to some extent for the production of sugar cane, which yields from 10 to 20 tons per acre, and a part of it is kept in pasture. The main value of this land, however, is its adaptability for growing a superior type of cigar wrapper and filler tobacco. For this crop the Vivi sandy loam holds first place among the soils of the area. The areas in the higher mountain valleys are said to be very similar in character of soil and their relation to drainage and climatic conditions to the valuable tobacco soils about Comeiro. The yield of tobacco on the Vivi sandy loam ranges from 600 to 800 pounds per acre. The tobacco industry around Utuado is being developed principally on this soil.

The following table shows the mechanical analyses of representative samples from the bottom lands near Utuado:

Mechanical analyses of Vivi sandy loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6495	1 mile W. of Utuado.	Sandy loam, 0 to 10 inches.	0.72	0.35	6.77	18.37	41.70	16.89	11.49	4.73
6497	1 mile N. of Utuado.	Yellowish-brown sandy loam, 0 to 10 inches.	.89	.70	10.02	16.91	28.37	11.73	18.39	12.90
6496	Subsoil of 6495	Sandy loam, 10 to 36 inches.	1.00	.44	4.15	7.39	28.24	19.58	21.95	17.79
6498	Subsoil of 6497	do	.87	.60	5.65	8.11	24.81	15.06	27.34	18.83

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ADJUNTAS CLAY.

The Adjuntas clay, locally known as "the red-clay land," is a pink, red, or dark-brown clay 3 to 8 inches deep, underlain by a red or pink clay subsoil 20 inches or more in depth. In some areas landslides and road cuts show the soil covering to be as much as 15 feet in thickness, grading into the decomposed volcanic and igneous rock which underlies the whole area. The difference in color is due to the state of weathering and the presence of more or less vegetable matter in the soil, the darker brownish soils being found chiefly in the virgin lands or at the base of the slopes where there has been an accumulation of humus in the washings.

This soil type occupies one very large area around Adjuntas, extending across the area surveyed from east to west and lying along the western boundary for some distance north of Utuado. There are also two small areas northeast of the latter town.

The topography of the Adjuntas clay is rough and mountainous, with many steep slopes and deep, narrow valleys. There is therefore much less trouble from lack of drainage than from the washing of the soil. Under the torrential downpour of tropical storms the erosion is very severe, and great care has to be used in the handling of this soil in the exposed situations.

In origin this soil is residual, being formed by the breaking down and decay of the igneous and volcanic rocks that form the backbone of the island. This disintegration has taken place to considerable depths, as shown by the soil mantle, in some places reaching a depth of 15 feet, the rock often showing decay beneath this.

The Adjuntas clay is next in importance to the valuable sugar lands of the coastal plain region, being the principal soil upon which coffee is grown. The yield upon the richest lands—those containing the most humus—reaches 400 pounds of the dried bean per acre. The product on this soil type is also the best in the area, the price for the better grades being $3 per 100 pounds higher than for the coffee grown on the Tanama stony loam, for instance. Many coffee estates are located in this area, some of which have large tracts under cultivation. The majority of owners, however, were left in such poor circumstances as a result of the hurricane of 1898 that they have been unable to replant or to keep up their estates. In many cases the ferns and vines have completely covered the few remaining trees.

Throughout the area a few well-regulated estates show what can be done with care, but only persons with means, who can put estates in good condition and wait for returns until the trees come into full bearing, can expect to make much of a success in the cultivation of this crop at the present prices.

Several of the coffee estates have orange trees here and there among the coffee trees and along the trails. They are usually of fair size,

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THE TANAMA STONY LOAM, PORTO RICO, SHOWING ITS VERY ROUGH AND RUGGED TOPOGRAPHY, ALMOST INACCESSIBLE AND IMPASSABLE, MUCH OF IT IMPOSSIBLE OF CULTIVATION.

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BANANA GROVE ON ARECIBO SANDY LOAM, NEAR SANTA ANA, PORTO RICO.

In the stony and mountainous areas the banana, plantain, and coffee trees are put out often in small patches, receiving little or no attention.

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well laden with fruit, and superior to the trees seen in any other locality in the area, with the exception of those found on the area of Alonso clay to the southwest of Adjuntas.

On the completion of the military road, giving good and easy communication with Arecibo and Ponce, the Adjuntas clay adjacent to the main road will undoubtedly offer some of the best opportunities for citrus fruit cultivation to be found in the area. Large quantities of bananas, plantains, Yantia, and malanga are grown to supply the laborers of coffee estates and the people of the south side of the island, where it is in many places too dry for the cultivation of these food crops.

The following table shows the mechanical analyses of samples of Adjuntas clay:

Mechanical analyses of Adjuntas clay.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6556	½ mile W. of Adjuntas.	Dark-colored clay loam, 0 to 18 inches.	3.17	0.66	1.40	1.50	7.46	8.90	38.62	41.04
6589	8 miles N., 3 miles W. of Ponce.	Clay, 0 to 6 inches..	1.36	.16	.52	.46	2.22	3.48	35.80	56.64
6555	3 miles N. of Penuelas.	Light-colored clay, 0 to 36 inches.	.64	.74	1.12	.78	3.04	4.34	32.56	57.84
6557	Subsoil of 6556......	Red clay, 18 to 36 inches.	1.10	.30	1.50	1.70	6.60	8.46	52.30	28.94
6590	Subsoil of 6589......	Clay, 6 to 36 inches..	.91	.00	.28	.40	1.94	3.70	35.20	57.52

PORTUGUES ADOBE.

The Portugues adobe is a heavy dark-brown loam resembling adobe, underlain by material of a somewhat similar character, but of a lighter color, which gradually grades into a light yellow as the depth increases. The soil is formed from the decomposition of limestone, a few fragments of which occur in some areas. These are a more prominent feature of the area west of Ponce, where a light-colored phase of this type occurs. Owing to its heavy, plastic texture, the soil is very difficult to till.

The Portugues adobe occurs only on the south or semiarid side of the island, in a number of areas of regular outlines. It occupies valleys and gentle slopes in the limestone hill region, partly above present irrigation systems. The greater part of the higher-lying areas are

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very uneven, so that even if water could be brought to this level irrigation would be a costly operation.

Previously to the hurricane of 1898, which destroyed many mills and cane fields, leaving some of the planters in such circumstances that they were unable to rebuild their mills or replant their fields, the lands under irrigation were mostly devoted to cane. Since that time, however, these lands for the greater part have been used for pasture, to which use the lands above irrigation have always been put. They are now being gradually replanted, and it is only a question of time when they will once more be cane fields. With sufficient moisture, good crops are raised, the cane carrying a high per cent of sugar. This soil ranks fourth of the soils of the area, and third of the irrigated soils, in the production of cane. The yield varies from 15 to 30 tons per acre.

Tobacco is also grown on this type. The quality is said to be very good. The leaf is used chiefly for the manufacture of cigarettes. One field of about 30 acres was seen on the light-colored phase of soil west of Ponce. This was under irrigation and had been planted to tobacco for the last three years. Several crops were harvested from each planting, and the leaf secured was of a type suitable for cigar wrappers and fillers. The proprietor of this tract said he should abandon the growing of tobacco with the end of the present season and put the land again in sugar cane.

Bananas are also grown on this type, and where the land is level enough to permit irrigation and the supply of water plentiful the yields are very satisfactory. As many as 700 bunches have been gathered from 1 acre in a single year.

The following table shows the texture of typical samples of the soil and subsoil of this soil type:

Mechanical analyses of Portugues adobe.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6580	2¼ miles W., ¾ mile S. of Ponce.	Dark-brown loam, 0 to 16 inches.	0.88	0.46	1.80	2.00	7.10	12.80	42.66	32.40
6582	1 mile W., ¼ mile N. of Ponce.	Heavy dark-colored loam, 0 to 17 inches.	2.17	1.60	2.80	2.20	7.00	11.68	40.46	34.26
6583	Subsoil of 6582......	Light-brown heavy loam, 17 to 36 inches.	.75	.46	1.56	1.34	3.12	6.66	49.24	37.02
6581	Subsoil of 6580......	Light-brown loam, 16 to 36 inches.	4.61	1.14	2.62	1.82	6.00	11.56	38.12	38.74

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PORTUGUES STONY LOAM.

The soil of the Portugues stony loam is a dark loam of an average depth of 14 inches. Intermingled with the fine material is from 20 to 60 per cent of angular stones, the whole resting on a bed of fragments of partly decomposed volcanic and igneous rock. The depth of the soil mantle varies greatly, being shallow on the hills and steeper slopes and much deeper along the northern and southern borders of the area, where, too, the content of rock fragments is lowest. This variation is due almost wholly to erosion, though the greater depth in the north may be due in part to the more rapid breaking down of the parent rock under the influence of heavier rainfall. Along the northern edge of the area the soil becomes of a lighter color and grades into the Adjuntas clay.

The Portugues stony loam occupies a single large area between the soils of the south coast limestone hills and the Adjuntas clay of the higher altitudes. The surface of the greater part of the area is rough, hilly, or semimountainous, and characterized by many steep slopes. The hills become more rounded in the southern parts of the area.

This soil is residual, being derived from the weathering of volcanic and igneous rocks. Judging from the depth of the soil, notwithstanding the known excessive removal of soil by washing, the rate of weathering must be comparatively rapid. The soil does not rest upon fresh rock, as in the limestone regions, but passes by degrees through a broken mass of partly disintegrated rock to the solid rock bed below.

In the southern part this soil is devoted largely to stock raising, while in the northern part bananas and plantains are raised in considerable quantities, and some coffee estates, not in the best condition nor yielding very well, are found in the more favorable situations. Nowhere else on this soil is coffee culture so successfully carried on. In some of the deeper soils of the southern border of the type sugar mills have been built and cane planted; but it has been found that the rainfall is insufficient for the profitable prosecution of this industry and stock raising has been substituted by the owners of these plantations.

The following table gives the mechanical analyses of this soil:

Mechanical analyses of Portugues stony loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6584	4¼ miles N. 1¼ miles W. of Ponce.	Stony loam, 0 to 14 inches	1.11	20.46	19.36	7.20	10.50	8.78	18.92	14.68
6585	6¾ miles N. 2¼ miles W. of Ponce.	Stony loam.........	3.31	10.40	10.70	6.10	11.66	9.50	29.40	22.14

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PENUELAS ADOBE.

The Penuelas adobe is a brown loam having the characteristics of an adobe soil, an average depth of 13 inches, and resting directly upon a mass of disintegrated volcanic tufa. The soil is heavy and plastic when wet and is difficult to till, and when dry it bakes and cracks. This type is found only in one area, which, however, is of considerable extent, covering the hills and slopes around the town of Penuelas.

Because of the prevalence of drought in this part of the island this type is used for little except pasture. During the wet season a good covering of grass is produced. Bananas and plantains are found, but only in exceptionally favored positions, where there is sufficient moisture, do they amount to anything.

Mechanical analyses of Penuelas adobe.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
6562	1½ miles NE. of Penuelas.	Light-brown loam, 0 to 15 inches.	1.13	6.20	8.54	5.30	10.98	9.28	23.32	36.28
6561	1 mile N. of Penuelas.	Brown loam, 0 to 13 inches.	1.29	1.56	2.88	2.22	6.70	8.54	31.56	45.90
6563	Subsoil of 6562	Gravelly loam, 15 to 24 inches.	.92	30.28	20.66	7.94	13.30	9.40	8.64	9.42

PASTILLO LOAM.

Pastillo loam is a loam soil 4 to 36 inches in depth, but over much of the area nearer the minimum depth. The color shows a wide variation, ranging from almost chalky white to a reddish brown and black. The soil rests directly on limestone rock, of which it contains many fragments.

This type occurs in one large and three smaller areas on the south side of the island, the greatest extent being west of Ponce. The surface is gently rolling. It covers limestone hills of rounded contour and easy slopes.

The soil is of little agricultural value. In a few spots where the soil is deepest there are a few areas cleared and planted in Guinea grass, which is used for pasture or cut for hay. The remainder of the area is covered with a growth of brush which in some places is very dense

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and from 10 to 15 feet in height, furnishing a small amount of firewood and perhaps some browsing for cattle. Were the hills free from this growth they would undoubtedly produce much more grass than at present; still, it is very doubtful if the return would pay for the cost of clearing, for over the greater portion of the area the soil is too shallow to support more than a short growth of grass and that only during the wet season.

The following table gives the mechanical analyses of this soil:

Mechanical analyses of Pastillo loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6565	3¼ miles SW. of Ponce.	Loam, 0 to 4 inches.	13.36	7.51	8.52	3.82	8.14	7.26	40.40	23.60
6564	1 mile N. of Ponce..	Light-colored loam, 0 to 36 inches.	3.22	.86	1.60	1.64	6.60	10.88	51.14	26.88

PONCE LOAM.

The Ponce loam is a dark-brown alluvial loam, at least 3 feet deep, underlain by material of the same or perhaps slightly heavier character. The soil is somewhat heavier than the Ponce sandy loam, is harder to cultivate, and is apt to clod and bake unless stirred when in just the proper condition. It is a strong, durable soil.

Two relatively small areas are found within the limits of the survey, the smaller situated southwest of and near Ponce and the larger southeast of that city. The surface of this type is nearly level, the slope being slight toward the south. Traversing this plain are shallow depressions, marking former courses of the river. These low spots were at one time covered with a heavy growth of swamp vegetation, and as a result the soil is rich in humus.

The soil being very heavy, the drainage is poor, except where the surface is more sloping. Artificial drainage of the depressions was necessary before they could be cultivated.

A small area near Ponce is planted in Guinea grass, large crops of which are cut several times each year. The remainder of this type is cultivated to sugar cane with the aid of irrigation. The yield per acre ranges from 35 to 40 tons per acre, and is equaled by only one other

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soil in the area—the Arecibo silt loam. As regards sugar content, the product of the Ponce loam is the first in the area. On some of this land sugar cane has been cut annually for a great number of years, and the rate of yield and the fertility of the soil has decreased as a result, though the yield probably averages twice that of the Southern United States.

The following table gives a mechanical analysis of this soil:

Mechanical analysis of Ponce loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6566	½ mile SW. of Ponce.	Dark-brown loam, 0 to 36 inches.	1.34	0.34	0.84	0.60	4.68	15.30	57.46	20.06

PONCE SANDY LOAM.

The soil of the Ponce sandy loam consists of a dark-brown sandy loam of fairly uniform texture, varying in depth from 2 feet to perhaps 10 or 12 feet. This is underlain by material of much the same character, varying slightly, being heavier than the surface soil in some places and lighter in others. A light phase also occurs along the river courses, where the surface soil is quite sandy and contains a few pebbles. In one or two places gravel was found scattered about on the surface or deposited in small channels cut in the soil. However, these variations were of little importance. This type occupies the level playa plain on the south side of the island, representing the flood plains of Tallaboa, Mayaguez, Portugues, and Bucana rivers and their tributaries. The plain has a moderate slope toward the ocean, but its surface is somewhat uneven and broken because of the shifting of the rivers, which have wandered to and fro over it.

It follows that this soil is of alluvial origin, the material of which it is formed being the finer particles of sediment borne by the rivers during floods from the hills and mountains farther back from the coast. The uniformity of texture and the fineness of the particles are due to the distance from the source of erosion and to the slower currents of the streams in this part of their courses.

There are two small bodies of a stony phase of this soil found in the area surveyed. These occur as narrow strips extending short distances along the Portugues and Tallaboa rivers, to which streams the

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formation is due. The material is the coarse alluvium, consisting of loam, sand, and gravel brought down by the rivers from the mountains during the flood season and deposited as the streams adjust themselves to the more gentle slopes of the valleys.

Sugar cane is the principal product grown on the Ponce sandy loam, irrigation of course being necessary. The yield is not so large as on the Ponce loam or the Arecibo silt loam, averaging from 30 to 35 tons per acre, or about 5 tons less than the yield of the two leading cane soils of the area. The sugar content is higher in the Ponce sandy loam, while the yield is almost if not quite equal to that of the Arecibo silt loam. The cane is grown year after year on the same fields, and there is a slight decrease in the yield from year to year.

Guinea grass is the crop next to cane in importance. Large fields in and around Ponce are devoted to its cultivation to supply the forage demand of the city. The grass is cut green, tied in bundles, and delivered fresh to the consumer each day. Like alfalfa, as soon as cut Guinea grass begins to grow again, and where sufficient water is furnished a large yield is cut several times during the year. Shade is supposed to increase the growth, and in the best fields mocha and other trees have been planted for this purpose.

Around several of the cane plantations fields of bananas, ranging from small patches up to 10 acres in extent, are planted, principally to supply the laborers with the fruit. The trees in these fields are very large and well loaded with fruit and this soil no doubt gives by far the largest returns per acre of any land in the area. A few cocoanuts are grown along the plantation boundaries, roads, and ditches, and in the latter places particularly the nuts are large and the yield very high—probably even higher than on the coral sands. A yield of 700 bunches of bananas per acre in one year has been grown on this soil. Sugar cane is now the great staple crop upon this soil type, and while it is very productive when cultivated in bananas and cocoanuts it is doubtful if it should be used in the commercial production of these crops as long as cheaper lands nearly as good for the purpose are obtainable. No attempt has been made to grow the citrus fruits on this type, but it is believed that with irrigation oranges and lemons would do exceptionally well.

A few attempts have been made to farm the stony phase of this soil to cane, but it seems these have not been profitable and all of the soil is at present used for pasture. A few cocoanut trees are also grown, but on account of the lack of moisture the yield is very light.

The table on the following page shows the texture of the soil and subsoil of this soil type.

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Mechanical analyses of Ponce sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6568	2 miles W. ¼ mile N. of Ponce.	Light-brown sandy loam, 0 to 14 inches.	2.30	0.52	1.30	2.64	24.40	23.76	39.26	8.08
6570	1¼ miles S. of Ponce	Light-brown sandy loam, 0 to 15 inches.	1.08	Tr.	.40	2.12	31.02	25.80	31.16	9.16
6579	1 mile N. ¼ mile E. of Ponce.	Dark sandy loam, 0 to 36 inches.	1.08	3.30	8.40	8.10	24.00	21.24	22.84	11.92
6572	2¼ miles SE. of Ponce.	Light-brown sandy loam, 0 to 36 inches.	1.46	2.30	1.86	1.70	10.54	19.98	50.82	12.50
6578	1 mile W. of Penuelas.	Brown stony loam, 0 to 26 inches.	.84	1.90	8.08	11.20	28.62	15.40	20.72	14.08
6567	7¼ miles W. of Ponce.	Alluvial soil, 0 to 36 inches.	.08	1.56	3.50	2.66	11.90	20.66	42.80	16.42
6571	Subsoil of 6570.....	Fine sandy loam, 15 to 36 inches.	1.19	.20	.30	.40	6.34	17.52	58.22	16.86
6569	Subsoil of 6568.....	Dark-brown loam, 14 to 36 inches.	.71	Tr.	.76	.80	6.90	13.50	56.02	21.76

TANAMA STONY LOAM.

The area mapped as the Tanama stony loam represents a group of soil conditions rather than one particular soil type. The prevailing type, however, consists of a red clay, generally shallow—only 2 or 3 inches deep—but frequently having a depth of several feet. The soil contains from 30 to 60 per cent of angular limestone fragments. Where the soil is more than a few inches deep the clay content increases considerably in the lower depths. Beneath the shallow covering of soil occur masses of broken limestone, or more often limestone in place. Usually the red clay is found to a greater extent on the upper slopes of the rough and broken land, but often one can travel for miles and find the red clay not only on the slopes but also in the small local bottoms or depressions. The soil is soft and unctuous, containing no noticeable particles of sand or any other than clay material.

Closely related to the red-clay areas are small areas of black adobe-like loam, which are interspersed throughout the area occupied by this formation. This loam is identical in almost every respect with the soil which has been described as Arecibo loam. In the small areas the depth of this black, tenacious loam rarely exceeds 6 inches, beneath which lies a shallow brown and occasionally red loam. The areas of this black loam are for the most part small, and although they sometimes occur on the higher slopes and on the crests of the hills, more fre-

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quently they are found on the lower slopes and in the depressions between the hills, wherever there is an accumulation of organic matter. Frequently in the small depressions swampy conditions prevail and cultivation is impossible. Where the drainage was still further obstructed the depressions contain small ponds.

In many places rock walls, with perfectly bare surfaces, from a few feet to more than 150 feet in height were observed. Occasionally a bush or shrub may be seen clinging to some crevice, but in most cases the rocks are devoid of vegetation, except, perhaps, the overhanging roots of trees or shrubs growing on the ledge above and the long vines which extend to the bottom of the cliff. Frequently on the crests of the hills, where there is only a slight soil covering, the limestone is so porous and open and the conditions of heat so favorable that many plants and trees and even a thick covering of grasses find a footing on what might be termed the bare rock surfaces. Often small, angular hills, rarely exceeding more than a few acres in extent and from 100 to 200 feet in height, from which the thickly matted jungle of trees and underbrush had been removed, were seen supporting a thick growth of long grass. A careful examination of some of these hills failed to reveal any soil covering whatever. (See Pl. LIX.)

The principal area occupied by the Tanama stony loam is situated on each side of the Arecibo River, commencing 4 miles south of Arecibo and extending to the junction of the Limon and Caguantas rivers with the Arecibo. It covers the greater portion of the area described in the physiography under the name of eroded limestone plateau or foothill region which lies to the north of the central mountainous region. At the southern extremity of this soil formation the hills range in elevation from 100 to 200 feet, from which they gradually rise to the southward until, along the line of contact with the mountains, they attain an elevation of nearly 1,000 feet above sea level. This region was undoubtedly at one time a continuous table-land sloping gradually seaward. It is now so pitted and broken that its once level character can only be realized by viewing it from the top of one of the surrounding hills. Although the hills attain a height of 1,000 feet along the southern edge, the difference in elevation of the summit of the hills and of the bottom of the intervening pits seldom exceeds 500 feet. Along the northern and southern boundaries of this soil area the intervening valleys are frequently larger than in the central portion, where the hills are more closely packed together. Travel on the narrow and winding trails that cross the greater portion of this area is exceedingly slow and laborious.

This region is drained almost entirely by underground streams. Only the Arecibo and Tanama rivers cross it, flowing through deeply cut canyons. Nearly all of the depressions have holes in them which serve as outlets for the heavy rainfall or for the water from the springs

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which are frequently found on their southern side. When the underground streams become clogged, the swampy condition previously mentioned arises and in some cases the water accumulates to a depth of several feet.

This soil type has been formed from the hard and soft layers of the chalky white limestone of Miocene age. The soil is residual and represents only the insoluble parts of the limestone after it has been thoroughly decomposed and leached by the abundant rainfall. Disintegration plays but little part in the formation of this soil, for the broken fragments of scattered rock through the soil show few traces of disintegration, but are comparatively fresh and solid. That the erosion of this area has been brought about by solution is readily seen when one considers that nearly all of the rainfall flows away to the sea by underground streams and observes that the region is fairly honeycombed in almost every direction by numberless caverns.

Over the greater part of the area bananas and plantains form the leading crops. Yantia, sweet potatoes, gondules, and melanga and other minor produce crops are grown to a considerable extent. Coffee is cultivated, but the greater part of this soil is too stony to allow the coffee roots to become well developed. The best coffee is grown in the southern part of the area, but it is inferior in quality to coffee grown on the Adjuntas clay, particularly in the higher altitudes, bringing about $3 less per 100 pounds. It is frequently the case that the small areas on the angular hills, where almost nothing can be seen but a mass of blocks of white limestone, are selected for tobacco, and it is said that these are more favorable situations for this crop than the lower slopes, where deeper soils are usually found. Possibly in such localities the conditions of light and warmth are more favorable to the rapid maturing of this plant, for the rocks absorb the heat from the sunshine during the day and remain quite warm during the night. It is only with abundant dew and frequent showers that a crop of any character can be raised in such unfavorable situations. The quality of the leaf is said to be very good. A sweet, well-flavored orange is grown on this soil, and the trees noticed seemed to be in fairly good condition.

Undoubtedly the red clays and black loams are fertile soils, but the rough, broken character of the country is decidedly against any great agricultural development in these regions. The trails are so difficult that transportation of large quantities of any product will always be a serious problem. At present all the products of this region are either carried on the heads or shoulders of the peons or on the backs of the small, hardy horses and mules that are raised on the islands. With the exception of the military road between Arecibo and Utuado, nothing but rough, winding trails (and only a limited number of these) traverse the area.

The table on the following page shows the texture of typical samples of the red clay and black loam soils of this area.

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Mechanical analyses of Tanama stony loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6488	5 miles NE. of Utuado.	Rich, black, tenacious loam, 0 to 6 inches.	7.76	0.77	1.68	1.61	9.04	7.43	45.08	31.41
6486	5 miles S. of Arecibo.	Clay loam, 0 to 10 inches.	1.77	.23	4.71	5.47	17.38	10.07	13.33	48.29
6489	5 miles NE. of Utuado.	Stiff red clay, 0 to 8 inches.	3.82	.00	2.01	2.22	6.72	3.26	35.29	49.78
6487	Subsoil of 6486.....	Stiff red clay, 10 to 30 inches.	1.82	Tr.	2.84	14.19	41.82	7.58	5.18	28.79
6490	Subsoil of 6489.....	Stiff red clay, 8 to 24 inches.	1.92	.43	2.78	3.19	11.05	3.94	25.55	51.14

WATER SUPPLY FOR IRRIGATION.

Irrigation on the north side of the island is only necessary in the cane fields in the dry seasons. The application of water during this period undoubtedly increases the growth of young plants and keeps the mature cane in a better condition for grinding, and there is an abundant water supply in the Arecibo River which can be made available for irrigation at very little cost.

On the south side of the island much of the arid land lies high up in the mountains or on the tops of the limestone foothills, and is unirrigable on account of its position. Within the area surveyed all of the available river water during the dry season is now used for irrigation. This supply, however, is inadequate, much of the young and some of the old cane showing the effect of drought. The supply should be supplemented by pumping from driven wells. This method has not as yet been attempted, but there are indications that driven wells would reach a good supply of water at moderate depths. The character of the water now used in irrigation is excellent.

The best quality of cane and the largest yields of this product, of bananas, plantains, and Guinea grass produced in the area, are obtained from the irrigated lands about Ponce, and with enlarged and perfected irrigation systems, so that the supply of water need never be short, not only will the acreage of cultivated land be extended, but the average yields will be materially increased.

UNDERGROUND WATER AND DRAINAGE.

During the wet months the level sugar lands of the north side are to a certain extent affected by the rising of the water table, which at

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that time comes to within a very slight distance of the surface of the ground. This, if not injurious to the growth of the cane, at least lowers the sugar content. The water table can be controlled by drainage, and is in a measure so controlled. This is generally done by means of open ditches which divide the field into many small tracts, thus interfering more or less with cultivation. Tile drains for carrying the surplus water off underground would be a great improvement over the present method.

There are several areas of swamp and other lands that are at present covered with water, or are too wet to permit of cultivation, which can be turned into valuable cane lands by drainage. In some places, on account of the slight elevation, the fall would not be adequate to keep the drains dry, and pumping plants would therefore have to be installed to move the water. It is doubtful if the profits to be made at present in the culture of sugar cane—the crop best adapted to such land—would pay for the reclamation of the less advantageously situated of these wet lands.

ALKALI IN SOILS.

Very little of the soil of the area was found to be alkaline, and all affected areas, with the exception of a strip along the Tiburones Canal, occur on the south side of the island. The areas there are low lying, and can not be reclaimed by underdrainage except by the use of dikes and pumps. The sea is thought to be the chief source of the salt in this area.

AGRICULTURAL METHODS.

In general, the agricultural methods of the island are primitive as compared with the methods in use in the United States. The implements and machinery, except on some of the large sugar and coffee estates, are antiquated and do the work for which they are intended but imperfectly. In many of the districts wooden plows are still used to stir the ground, while the bulk of the other farm operations falls upon the machete—a heavy sword or cutlass.

The care of the soil as it is understood in this country—the maintenance of its fertility by the addition of manures or fertilizers and the husbanding of its resources by the rotation of crops—is practically unknown in the island agriculture. The nearest approximation to this is allowing the land to "rest," i. e., throwing it out of cultivation for a year or two. These lands are generally used as pasture for the work oxen.

It is needless to say that under such conditions the fertility of the soils have greatly deteriorated. This is shown by comparing the present yield of the sugar-cane soil, which has perhaps been most

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intensively cultivated, with the yield fifty or one hundred years ago. The decline has been marked, and in all the island there is said to be but one exception to the general rule—the cane lands of the tributary island of Vieques. Nevertheless it should be borne in mind that the average product per acre in Porto Rico is about twice that of Louisiana, and that the cane grows from rattoons for from four to seven years after planting, while in Louisiana the fields must be planted anew each year.

To obtain some light upon the chemical nature of these Porto Rican soils a number of samples were analyzed in the laboratory according to the method of the Association of Official Agricultural Chemists, and from the data thus obtained the following observations were made:

The Adjuntas clay runs high in alumina (Al_2O_3) and iron (Fe_2O_3), containing about 20 per cent of the former and from 10 to 20 per cent of the latter substance, the iron running much higher in the subsoil than in the surface soil. The soil was rich in lime (CaO), containing about 0.5 per cent, and is apparently well supplied with nitrogen (N), containing about 0.15 per cent. It runs low in phosphoric acid (P_2O_5), containing only about 0.03 per cent, and shows but traces of potash (K_2O). In these latter two important plant foods this soil seems to be decidedly deficient.

The Alonso clay was found to contain about 14 per cent of alumina and about the same amount of iron oxide. It contains about 0.25 per cent of lime and more than three times this quantity of magnesia. It is well supplied with potash, about 0.6 per cent, and with nitrogen, about 0.12 per cent, and but fairly well with phosphoric acid, about 0.08 per cent.

The Pastillo loam contained about 2 per cent each of alumina and ferric oxide. It ran very high in lime, containing over 50 per cent of this substance. It was fairly well supplied with nitrogen, about 0.14 per cent, but was low in potash, 0.15 per cent, and contained but little more than a trace of phosphoric acid.

The Ponce sandy loam contains from 8 to 10 per cent of alumina and from 6 to 8 per cent of ferric oxide. It is well supplied with lime, from 2.5 to 5.5 per cent, and with potash, from 3 to 4.5 per cent. It contains about 0.09 per cent of phosphoric acid, although one sample examined ran as low as 0.03 per cent in this constituent. It seems fairly well supplied with nitrogen, containing about 0.12 per cent.

The Portugues adobe contains about 9 per cent of alumina, 5 per cent of oxide of iron, and is rich in lime, from 12 to 16 per cent. Of potash about 0.4 per cent was found, of phosphoric acid about 0.2 per cent, and of nitrogen about 0.25 per cent. A sample of subsoil in this formation showed over 1 per cent of sulphuric acid (SO_3), probably combined for the most part as gypsum, but the surface soil to a depth of 17 inches taken at the same spot showed but 0.03 per cent.

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All these soils, excepting possibly the Alonso clay, are rich in lime. While well supplied with magnesia, this soil constituent never approximates in amount the lime, except in the case of the Alonso clay as cited above, and this fact is a notable characteristic of these Porto Rican soils, no matter what their origin may have been. Excepting the Adjuntas clay, all the soils examined seemed to be well supplied with potash and fairly well with phosphoric acid. All may be considered as fairly well supplied with nitrogen, and under good cultural methods crops should not suffer seriously for the lack of this important and expensive plant food.

Coffee is the leading product of the island at large and of the district surveyed, though no statistics can be segregated for the fractional part of the district of Arecibo and Ponce which the survey covers. The principal coffee districts are around Adjuntas and Utuado, and the soils best adapted to the cultivation of this crop are the Adjuntas clay, the Alonso clay (high area southwest of Adjuntas), and the Utuado loam. The northern part of the large area of Portugues stony loam and the southern part of the even more extensive Tanama stony loam also produce some coffee.

The method of cultivating this crop, which differs little in the different areas, is as follows:

If the land is virgin, it is first cleared of trees and underbrush with the machete; then holes are dug, also with the machete, at the proper intervals, and the seedling trees are set out; or if the plantation is to be started from the seed, which is rarely the case, these are pushed into the soil and covered. Before or at the time of setting out the trees plantain or banana slips are also put in here and there to furnish shade during the first five years' growth. Guava trees are also set to furnish shade during the following years of growth.

The coffee trees begin to bear a little the fourth year from planting, but do not come into full bearing until the eighth year. The life of the tree, if given good care, is from fifteen to twenty years. As at present grown the coffee plants are greatly overcrowded as well as overshaded. The yield varies, the best managed estates gettir from 200 to 400 pounds per acre.

The harvesting is a laborious process, the berries being picked by hand as they ripen. The ripening of the berries is not uniform, and the plantations have to be gone over by the pickers several times to complete the gathering of the crop. Men, women, and children do this work, for which, on some plantations, they are paid by the weight of the green berries picked—about 40 cents per 100 pounds. A man can gather, where the trees are well filled with fruit, perhaps 100 pounds a day, but where the crop is poor or after the plantation has been gone over the amount is necessarily much smaller. Where wages are

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paid 35 cents a day is about the average, and this not all in money, but part in supplies advanced by the stores.

The coffee plantations are not cultivated. The situations are often very steep, and the roots of shrubs and vines are depended upon to a great extent to hold the soil in place. The undergrowth is kept down with the machete, and this generally constitutes the entire care.

After the gathering of the berry the preparation of the coffee for the market partakes rather more of the nature of manufacture than agriculture. The methods employed on the island vary all the way from the use of the simplest devices by the peons in the preparation of the few pounds they may gather from wild trees or filch from neighboring estates, through rude machinery worked by water or horse power, to the large mills equipped with modern types of machinery and usually operated with steam engines. Not to go into the details of the preparation of the coffee berry, the method consists of the removal of the pulp, the separation of the twin coffee grains, the drying and removal of the hull which envelops these, and the grading, polishing, and coloring of the coffee bean.

The coffee of Porto Rico goes almost entirely to Cuba, France, and Spain, and the average price paid by the exporters in the coast towns is about 10 cents per pound. Up to the time of the American occupation of the island little if any of this coffee came to the United States. It is said to be of a quality superior to the South and Central American coffee, which practically monopolizes the United States market. The South American coffee brings a much lower price to the grower than the Porto Rican, but with closer trade relations established with this country doubtless Porto Rican coffee will soon find a place as a high-grade article in our market.

On a few coffee estates small areas have been fertilized with barnyard manure, coffee hulls, or guano. On gentle slopes the fertilizers were spread broadcast over the surface, while on the steep inclines it was dumped in piles and allowed to leach downhill, or put in holes about 1 foot square and 1 foot deep between the plants. The latter method proved more satisfactory because of the less loss by washing. With heavy applications of the fertilizers the coffee plants are said to more than double their yields.

In many of the caves which practically honeycomb the limestone portion of the island bat guano covers the floor in places to a depth of several feet. There are thousands of tons of this guano thus safely stored away in the mountains. In some localities the guano is hauled out and delivered for $3 per ton. At this price it is cheap plant food and its use can be recommended.

The preparation of the soil for sugar cane is more elaborate than for coffee. The land is usually plowed three times (the heavier soils four times) before the canes are set out. Ditches and drains are dug, and

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the cane is set on the sides of ridges, with a drainage furrow between the ridges, the land being laid out in such a manner as to allow the alternation of the ridges and furrows from year to year. The crop is weeded usually four times, and this is followed by the operation called "thieving," i. e., pulling the lower blades of the cane and laying them between the rows, where they form a mulch and keep the weeds and grass from growing. This represents the course of cultivation in a newly planted field. The labor is somewhat less in subsequent years. The cane reproduces itself from rattoons, and can be profitably grown without replanting for from four to seven years, though it is thought annual planting, using the modern methods employed in Louisiana and Hawaii, would return even greater profits.

In harvesting the cane is cut and hauled to the mill in ox carts, or on some of the best equipped plantations steel tramways with portable extensions run between the fields and the mill. The transportation of the cane to the mill is a laborious and expensive process, and where the haul is long it often turns the scale from profit to loss.

Fertilization of the sugar-cane lands is not commonly practiced, but experiments have been tried on certain estates with success. It was found that 1 cubic foot of stable manure to the hill gave better results than 1 pound of guano, the effect being more noticeable in the vigor of the rattoons and the increased productiveness in the second year than in the yield from the planted cane. Liming the soil has also been tried and is said to give good results.

The important sugar-cane soils are, in the order of preference, the Ponce loam (irrigated), Arecibo silt loam (unirrigated), Ponce sandy loam (irrigated), Portugues adobe (irrigated), and Vivi sandy loam (unirrigated). Between the first two types there is not much choice, the higher sugar content of the product grown on the one about compensating for the higher yields on the other.

The cultivation of tobacco follows more or less the methods employed in Cuba. The plants are transplanted from seed beds to the carefully prepared fields and given clean culture. The plants are budded, and a close watch is kept for the eggs and larva of the tobacco worm and other insect pests. Several crops are gathered from the same field in a single season.

While the methods of cultivation and curing are in many ways similar to those employed in Cuba, the Porto Rican grower is not generally as skillful as the Cuban. The industry has not reached as high a state of development as it has on the larger island.

The fields within the area surveyed are for the most part small patches, and this in itself is against the proper curing, sorting, and grading. In fact, the grower seldom attempts any grading at all, but sells his product in bulk, the grading being done by the exporter or the manufacturer.

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The tobacco is cured without the aid of artificial heat, the time of curing being about forty-five days. In some parts of the island the tobacco barns are loosely constructed sheds, generally built lengthwise up and down the hills, so that a draft will blow through them as through a chimney; but in the area surveyed the barns, which were heavily thatched, were built horizontally and without regard to special ventilation.

The best grade of tobacco, which is grown in the mountain regions, compares favorably in natural characteristics with some of the better classes of Cuban tobacco. The Vivi sandy loam produces the finest leaf in the area, the Arecibo silt loam (sandy areas along the upper course of the river) having second place, the Adjuntas clay third, and the Tanama stony loam fourth. Tobacco on the Portugues stony loam is grown under irrigation.

Up to this time coffee, sugar, and tobacco have been the chief exports from the island. Besides these crops there are a large number of fruits produced on the island, some of them cultivated, but many of them growing wild, and the minor subsistence crops, important among which are tanier, sweet potatoes, cassava, upland rice, beans, and corn. As yet in the areas surveyed little attempt has been made to grow any of these products on a commercial scale, but there seem to be good prospects, with the close trade relations which now exist between the island and the United States, for the development of favorable industries in the production of citrus fruits, cocoanuts, pineapples, and bananas, as well as some of the other fruits not as well known in the markets of this country; for instance, the guava in the shape of jelly.

Citrus-fruit culture as it is carried on in California and Florida is practically unknown in Porto Rico. The orange, which is the most important and most extensively grown of these fruits, is planted among the coffee trees, in the shade along the trails, and around the houses, but after planting little else is done to promote the growth and productiveness of the trees, except that on some estates the grass is occasionally cut from beneath them. With the little care just mentioned the trees grow vigorously and bear an abundance of fair fruit, sweet and of good flavor, and with small amount of pulp, medium thick skin, and good color.

Considering that nothing has been done to improve the native stock by budding or grafting, all the trees being seedlings, the fruit is very fine. Undoubtedly it could be improved by grafting from scions from selected trees on the island or by introducing some of the choice varieties from other orange-growing districts.

A few dozen lime trees were observed scattered through the area. They were of good color and bore considerable fruit, and there seems

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to be no reason why this fruit should not be grown successfully on a commercial scale.

Only a very few lemon trees bearing a coarse, inferior fruit, used only to a limited extent, were noticed. This same variety is grown in California gardens as a curiosity. The production of this fruit seems to be neglected. A fair idea of the lemon output may be drawn from the fact that the Italian product is the only kind to be found on the market. The pomelo, or grape fruit, reaches perfection on the island.

The cultivation of citrus fruits is recommended for the Adjuntas clay, the Alonso clay, particularly the high-lying areas to the southwest of the town of Adjuntas, and the Tanama stony loam, in such locations as are near enough to the military road to permit of the transportation of these crops to market. On all of these soils these crops could be produced without the aid of irrigation. On the south coast of the island, where the climatic conditions and soils are in some ways similar to those of southern California, the raising of citrus fruits under irrigation could be profitably undertaken. The Ponce sandy loam is one type of soil recommended for the growing of oranges. Near Mayaguez, in the extreme western part of the island, there are a few successful commercial citrus-fruit orchards, and there is no reason why other successful orchards should not be established on some of the soils of the area surveyed, and the direct water transportation between the island and New York, together with the low freight rates, should encourage capitalists to embark in the development of this industry.

To no other two products do the natives owe so much as to the banana and plantain. From playa plain to mountain top, wherever any cultivation has been carried on, the beautiful plants, of various heights, with broad, herbaceous leaves, 8 or 10 feet long, are seen. Bananas and plantains are grown from the suckers which appear at the base of large trees. These are separated from the parent tree with a spade or knife and transplanted. In one year from the time of planting the first fruit may be gathered. Bananas are always cut green, fifteen or twenty days before maturing, and hung in the dark to ripen.

There are more than a dozen varieties of bananas grown in the area surveyed. The "date" and "apple" varieties are by the natives considered the choicest. The former is about three or four inches long, with very thin skin, while the latter is a little longer. The plantain so closely resembles the banana that it takes an expert to tell them apart. There are many varieties on the island, the choicest of which are known as "hortones" and "congos." The fruit is gathered green and always prepared for eating by cooking.

Both bananas and plantains are used to a large extent to shade the coffee trees, especially the young plants. Better transportation facilities and the demand that is almost sure to arise in this country will soon develop the production of these crops along commercial lines.

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At present the soils on which bananas and plantains are more successfully grown, given in the order of precedence, are as follows: Ponce sandy loam, Arecibo silt loam, Ponce loam, Portugues adobe, Adjuntas clay, Alonso clay, and Tanama stony loam. When the question of commercial production is considered, the order may be changed somewhat, as cost of production and of transportation to market will enter more largely as a factor in the profitable growing of these crops. The best banana lands may yield as high as 700 bunches on a single acre in one year. (See Pl. LX.)

Probably the most valuable of the indigenous trees of the island is the cocoanut palm. It is cultivated to considerable extent in the area surveyed, but most successfully on the sands along the seacoast. The soils on which it does best are the Ponce sandy loam, the Coral sand, the Arecibo sandy loam, the Arecibo sand, and the Arecibo silt loam. Near the coast, where the water table comes near to the surface, the trees were particularly thrifty, on soil that is almost worthless for any other purpose.

The cocoanut palm grows to a height of 50 feet or more and is crowned with fronds from 12 to 15 feet in length. The fruit is borne in clusters, from 2 to 15 nuts in a cluster, and one tree sometimes bears as many as 150 nuts. As many as 10,000 nuts may be produced on one acre in one year. The tree begins fruiting when 5 years old and may continue to fruit for one hundred years.

Cocoanut trees require no cultivation when once established, but the gathering of the nuts is difficult and expensive, as is also the freeing of the nuts from their fibrous husks. No extensive plantations were seen in the area, but a few are sold for export, bringing from $12.50 to $20 per thousand. In the eastern part of the island some attention is given to the commercial production of this nut, and in 1890 1,500,000 cocoanuts were exported from the island, principally to the United States.

The Porto Rican pineapples are acknowledged, even in Cuba, to be the finest flavored in the West Indies, and yet but few are exported—only 50,000 in 1898. Within the area surveyed at present pineapples, with one or two exceptions, are grown only in small patches for home use, the poorest reaching the local markets. There is excellent opportunity for the introduction of the commercial growing of this crop. Certain of the cheapest sandy soils are very similar to the pineapple lands of southern Florida, and with the same high fertilization and intensive culture would probably become equally as valuable.

The guava, cassava (from which comes the commercial tapioca), and a number of other native crops also promise to become of economic importance when transportation facilities improve and the needs of the United States markets become understood in the island. The growing of some of the vegetables for early marketing in the United States might be profitably developed.

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AGRICULTURAL CONDITIONS.

At the time of the occupation of Porto Rico by the United States, agriculture in the island was greatly depressed. The low price of sugar in recent years had closed many of the mills and thrown out of cultivation wide areas of fertile sugar lands; the war in Cuba had unsettled trade with the mother country, and oppressive taxation, made more onerous in the attempt to make the little island bear a disproportionate part of the extraordinary expenditures necessary for carrying on the war, had discouraged those who were able to start new enterprises or to revive those in decline by the investment of capital. As a result of these untoward circumstances many of the laboring class were already out of employment when the disastrous hurricane of September, 1898, occurred. Although this storm did great damage to the sugar industry, it was the coffee plantations which suffered most heavily, and thousands of laborers in the coffee districts of the area surveyed were added to the army of the unemployed.

At the time of the present survey the damage wrought by the storm was still apparent on every hand, and the condition of general depression was only too evident, though matters were beginning to mend, primarily as the result of new governmental policies.

The removal of all personal taxes, the abolishment of the consumer's taxes on food and articles of necessity, the establishment of free trade between the island and the United States, and the hiring of thousands of laborers in the construction of roads are some of the acts of the new régime that are tending to relieve the situation.

While the farming class is as yet far from being in a prosperous condition, the noticeable improvement in that respect that has taken place in the last three years, together with the admitted opportunities for the development of paying agricultural industries and the certainty that capitalists will be found to develop them, holds out hope for the future.

A greater proportion of the farms in Porto Rico are owned by the occupants than in the United States, or than in most of the States taken individually. If we may take the percentages of the departments of Arecibo and Ponce as representing the area surveyed, between 96 and 97 per cent of the farms are owned and but something over 3 per cent are rented. When the land is rented to the peasant class, one-half the crop is the usual return to the owner, the tenant performing all the labor of clearing the land and caring for the crop. In the island at large 89 per cent of the cultivated area is occupied by whites, and 10 per cent by negroes and persons of mixed blood.

The average size of the farms in the area surveyed is probably not far from 50 acres, or a little more than one-third the average size of farms in the United States, and the average area cultivated is about

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one-fourth of the total area, while in the United States about one-half of the farm land is on the average improved.

The labor is performed largely by the peons, as they are called. The wage paid is about 40 cents per day, though in the sugar districts the rate is occasionally 50 cents. The latter rate is being paid where extensive operations in road building are being carried on. Often the employer gives the farm hands the midday meal.

The Porto Rican laborer is faithful and industrious, and, while he is illiterate (83 per cent of the entire population of the island is unable to read), he is intelligent, apt mechanically, willing to learn, and appreciative of fair treatment. With all the difficulties in the way of learning, the proportion of the literates in the island increased from 8 per cent in 1860 to 16 per cent in 1899. With the institution of the free school system the lifting of this class to a higher intellectual plane should progress rapidly.

With the low wage rate and the lack of opportunities for steady employment it is no wonder that great poverty is common among the laboring class. Were it not for the practice of frugality on the one hand and the lavish production of wild and cultivated fruits common in tropical countries on the other, so dense a population as that of Porto Rico under existing conditions would soon find itself on the verge of starvation.

In some of the farm work the women and young children assist. In the picking of coffee this is the case, and in the worming of tobacco, and other lighter work; but the women do not work in the fields as a usual thing as they do in Cuba and in some other of the West Indian islands.

Not to repeat what has been written of the crops in the separate treatment of the soils or in the chapter on cultivation, it is thought well to again refer to the principal products, this time with the broader view of their economic worth as a basis upon which to build a lasting agriculture. The production of sugar in this view is of prime importance. The industry should be resuscitated, and it will be. The quality of the sugar must be improved, the processes of manufacture cheapened, and the competition of other regions met. This can be done by the building of large modern mills in situations where sufficient cane lands can be made tributary to keep the machinery going constantly during the grinding season. In other words, there must be centralization—a reorganization of the industry along the lines in which there has already been made some advance. When so reconstructed the production of sugar will play even a more important part in the wealth and prosperity of the island and of the area surveyed than it does at present.

The Porto Rican tobacco is a fine cigar-filler leaf. It has been a practice of Cuban exporters, especially in years of short crops in that

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island, to buy the Porto Rican leaf and pass it off as "Habana." The tobacco industry in Porto Rico has scarcely been developed at all, notwithstanding that the quality of the leaf is good. It should be given the same skillful cultivation and curing that is given the Cuban product. Who can doubt that this product will some day be a mainstay in the agriculture of the island? It will affect mainly the central districts of the area surveyed.

Porto Rican coffee is of fine flavor and brings a better price to the grower than South American coffee. It has an established reputation in European markets. As yet it has not found favor in the markets of this country, but there doubtless will be a demand for it when it shall be introduced to that public which insists on a first-class article. It would seem that this market alone should cause a considerable increase in the area of coffee plantations. Coffee is now the most important industry in the interior areas of the area surveyed, and it is destined to become more important.

The fruit industry has been even less developed than the tobacco industry. The quality of those kinds for which there is already demand in our markets is superior, and amelioration of the present condition of the agricultural classes through the building up of commercial fruit growing is sure to take place.

Without drawing further upon the crop possibilities of the area, the above are enough to warrant a conclusion favorable to the future firm agricultural position of this new Territory.

In a region where so little of intensive agriculture is practiced it would not be expected to find the question of the adaptation of crops to soils worked out very carefully. Yet custom, the result of three hundred years, more or less, of empirical agricultural experiment, has determined broad soil-crop relations, and crop distribution is seen to follow soil formation and topography much as it does in the United States. The time has not yet come for much refinement in this direction, but the work of the agricultural experiment station in the island and of the Bureau of Soils will afford valuable suggestions for those that are ready for them.

Though outside of the area, an interesting instance of the progress of adaptation of soils to crops which has taken place around Cayey may be cited. This is the principal tobacco area in the island, producing a very fine grade of cigar wrapper and filler tobacco. Until within a few years the tobacco was all raised on the lower parts of the slopes, where the soils are deep and rich from the wash from the hills, but in some way it was discovered that the tobacco grown farther up the slopes was of even better quality, and the fields have now been extended to the crests of the hills.

Transportation facilities are limited within the area surveyed. Ponce and Arecibo possess harbors, or, rather, open roadsteads, where

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steamships call and receive cargoes of sugar, coffee, rum, and tobacco, but on account of the poor harbor facilities it is necessary for the large vessels to anchor offshore at both of these ports, and the cargoes are carried to the vessels in lighters. Two lines of steamships, with weekly service, connect the island with New York, while one of these lines also touches at South American ports. Other lines connect with the other islands of the Antilles and with Central and South American ports, and small vessels ply around the island.

Arecibo is connected with San Juan by the French Railroad, a narrow-gauge road, which carries freight and passengers. This is a part of the system of coast railroad which was originally designed to encircle the island, but afterwards given up. At the present time it runs from San Juan to Camuy, Aguadilla to Mayaguez, and from Yauco to Ponce.

The military road is completed from Arecibo to Utuado and is being constructed across the island. This will probably be finished by the end of the present year (1902), serving as an easy means of communication between the coast and the coffee districts in the interior mountainous regions. There are several ox-cart roads in the vicinity of the large towns, but travel over these during most of the rainy season is slow and painful.

In addition to these roads there are many trails which penetrate the country in almost every direction. These are only passable for pack horses, and frequently during the wet season they are unsafe for travel for either man or beast, on account of the slippery nature of the clay composing them. The question of transportation in the mountainous and limestone hill country is a serious one, and no considerable agricultural development can take place until suitable transportation facilities have been provided.

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APPENDIX.

(The publications having a price attached can be obtained from the Superintendent of Documents, Union Building, Washington, D. C., if the proper sum is sent in money order or currency.)

Field Operations of the Division of Soils in 1899. By Milton Whitney, with accompanying papers by Thomas H. Means, Frank D. Gardner, Clarence W. Dorsey, Frank K. Cameron, and Lyman J. Briggs. Pp. 198, pls. 29, figs. 19, lithograph maps 11. 1900. Price 95 cents. (30)

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Field Operations of the Division of Soils in 1900. By Milton Whitney, Chief of the Division, with accompanying papers by Thomas H. Means, Frank D. Gardner, Clarence W. Dorsey, Jay A. Bonsteel, William G. Smith, J. Garnett Holmes, Frank K. Cameron, Lyman J. Briggs, and Marcus L. Floyd. Pp. 474, pls. 51, figs. 47, lithograph maps, 24. 1901. Price, $1.80. (43)

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Field Operations of the Division of Soils in 1900—Continued.

Soil Survey of Cecil County, Maryland (375 square miles). By Clarence W. Dorsey and Jay A. Bonsteel.

Soil Survey of St. Mary County, Maryland (360 square miles). By Jay A. Bonsteel.

Soil Survey of Calvert County, Maryland (218 square miles). By J. A. Bonsteel and R. T. Avon Burke.

Soil Survey of Kent County, Maryland (315 square miles). By J. A. Bonsteel.

Soil survey from Raleigh to Newbern, N. C. (1,000 square miles). By William G. Smith.

Soil Survey in Weber County, Utah (307 square miles). By Frank D. Gardner and Charles A. Jensen.

Soil Survey in the Sevier Valley, Utah (220 square miles). By Frank D. Gardner and Charles A. Jensen.

Soil Survey in Salt River Valley, Arizona (370 square miles). By Thomas H. Means.

Soil Survey around Fresno, California (625 square miles). By Thomas H. Means and J. Garnett Holmes.

Soil Survey around Santa Ana, California (300 square miles). By J. Garnett Holmes.

Investigations on the Physical Properties of Soils. By Lyman J. Briggs.

Application of the Theory of Solution to the Study of Soils. By Frank K. Cameron.

Results of Tobacco Experiments Conducted in Various Parts of the United States. By Marcus L. Floyd.

Field operations of the Bureau of Soils, 1901. By Milton Whitney, Chief of Bureau, with accompanying papers by assistants in charge of field parties. Pp. 647, pls. 96, figs. 25, lithograph maps 31. 1902. Price, $2.25. (63)

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General Review of the Work. By the Chief of the Bureau.

Soil Survey in the Westfield Area, Chautauqua County, New York (260 square miles). By R. T. Avon Burke and Herbert W. Marean.

Soil Survey of Allegan County, Michigan (828 square miles). By Elmer O. Fippin and Thomas D. Rice.

Soil Survey of the Salem Area, New Jersey (493 square miles). By Jay A. Bonsteel and F. W. Taylor.

Soil Survey of the Lebanon Area, Pennsylvania (669 square miles). By William G. Smith and Frank Bennett, jr.

Soil Survey of Prince George County, Maryland (480 square miles). By Jay A. Bonsteel and party.

Soil Survey of Harford County, Maryland (418 square miles). By William G. Smith and J. O. Martin.

Soil Survey of the Bedford Area, Virginia (632 square miles). By Charles N. Mooney, F. O. Martin, and Thomas A. Caine.

Soil Survey of the Prince Edward Area, Virginia (430 square miles). By Charles N. Mooney and Thomas A. Caine.

Soil Survey of the Statesville Area, North Carolina (784 square miles). By Clarence W. Dorsey and party.

Soil Survey of Alamance County, North Carolina (365 square miles). By George N. Coffey and W. Edward Hearn.

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Field Operations of the Bureau of Soils—Continued.

Soil Survey of the Cary Area, North Carolina (63 square miles). By George N. Coffey and W. Edward Hearn.

Soil Survey of Cobb County, Georgia (346 square miles). By R. T. Avon Burke and Herbert W. Marean.

Soil Survey of the Covington Area, Georgia (225 square miles). By Herbert W. Marean.

Soil Survey of Montgomery County, Tennessee (547 square miles). By J. E. Lapham and M. F. Miller.

Soil Survey of the Yazoo Area, Mississippi (656 square miles). By Jay A. Bonsteel and party.

Soil Survey of the Yakima Area, Washington (309 square miles). By Charles A. Jensen and B. A. Olshausen.

Soil Survey of the Boise Area, Idaho (399 square miles). By Charles A. Jensen and B. A. Olshausen.

Soil Survey of the Hanford Area, California (216 square miles). By Macy H. Lapham and W. H. Heileman.

Soil Survey of the Lower Salinas Valley, California (344 square miles). By Macy H. Lapham.

Soil Survey of the Ventura Area, California (240 square miles). By J. Garnett Holmes and Louis Mesmer.

Soil Survey of the San Gabriel Area, California (259 square miles). By J. Garnett Holmes and Louis Mesmer.

Soil Survey of the Imperial Area, California (169 square miles). By Thomas H. Means and J. Garnett Holmes.

Soil Survey of the Willis Area, Montgomery County, Texas (215 square miles). By J. O. Martin.

Soil Survey of the Lake Charles Area, Louisiana (202 square miles). By W. H. Heileman and Louis Mesmer.

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